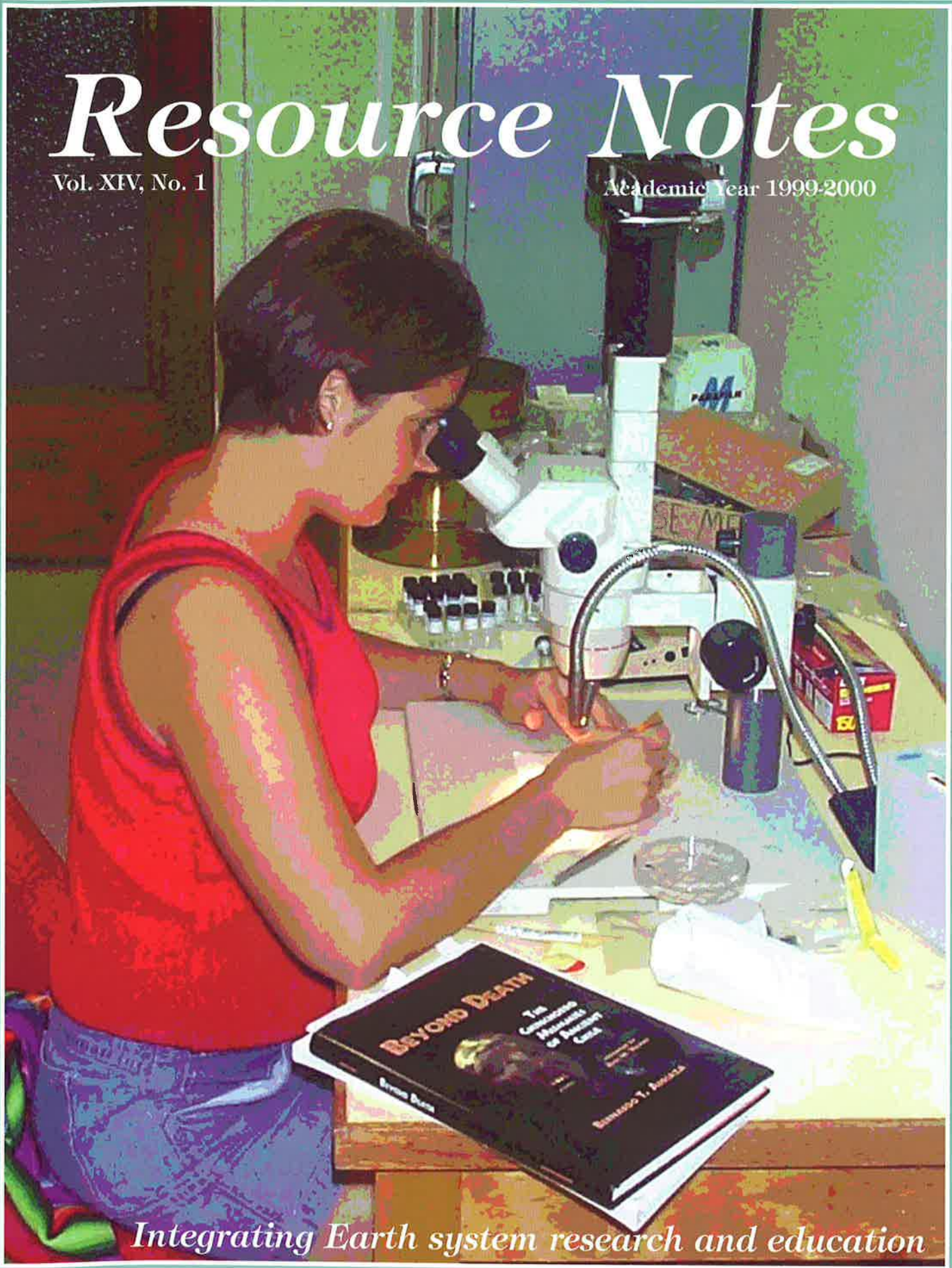
2000

Resource Notes-Academic Year 1999-2000

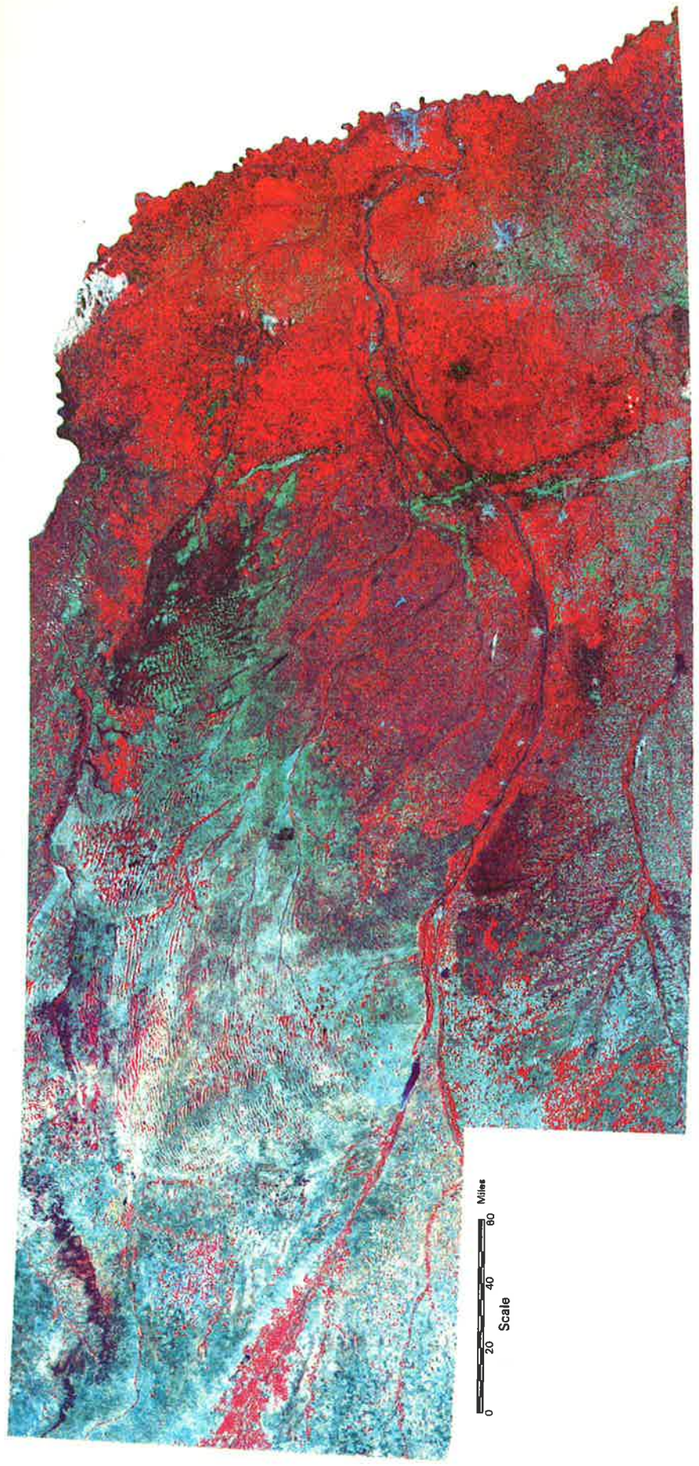
Resource Notes

Vol. XIV, No. 1

Academic Year 1999-2000



Integrating Earth system research and education



Satellite View of Nebraska

This is a mosaic of 18 Landsat Thematic Mapper (TM) satellite images acquired during the 1991 through 1993 growing seasons. Actively growing vegetation appears in shades of red. Areas having little vegetation cover, and areas where vegetation is dormant or dead at the time of imaging, have a bluish appearance. Water is dark blue to black. This data set has been used by the Nebraska Gap Analysis Project (GAP) to prepare a detailed map of Nebraska's land cover. GAP is a cooperative biological diversity project of the Center for Advanced Land Management Information Technologies (CALMIT), a joint program of CSD and the UNL School of Natural Resource Sciences (SNRS), and the U.S. Geological Survey's Biological Resources Division. It also involves a number of public and private state and local cooperators, including ecology and wildlife faculty of the SNRS and the state Game and Parks Commission. Copies of this image are available through the CSD Map Sales office at scales of 1:500,000 and 1:1,000,000. Contact CSD at (402) 472-7523 or email csdsales@unl.edu for details.

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***Resource Notes* is a quarterly publication of the Conservation and Survey Division (CSD) of the Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln (UNL).** The main office of CSD is at 113 Nebraska Hall, UNL, 68588-0517. The main number is (402) 472-3471; Map and Publication Sales is (402) 472-7523. *Resource Notes* is available free to all interested in earth science or other natural resources. To receive it, write or call the office above. The Conservation and Survey Division of the University of Nebraska-Lincoln is the agency designated by statute to investigate and interpret the geologically related natural resources of the state, to make available to the public the results of these investigations, and to assist in the development and conservation of these resources. The University of Nebraska-Lincoln does not discriminate based on gender, age, disability, race, color, religion, marital status, veteran's status, national or ethnic origin or sexual orientation.

Front cover: Melanie Olson, UNL graduate student in science education, examines fossilized intestinal contents from the mummies of a tribe of ancient Chilean Indians known as the *Chinchorro*. Olson participated in a four-week summer program cosponsored by the UNL Nebraska Earth Science Education Network (NESEN) and Teachers College and funded by the National Science Foundation. Aimed at integrating scientific research and education, it assembled teams consisting of an education student, a secondary-level science educator and a faculty member to investigate a variety of natural resource or agricultural topics. The image has been computer-enhanced through a process called *posterization* that forces color gradients into one block or another. NESEN photo.
Back cover: Kristina Nevius, UNL science education student, readies soil probes and other sampling equipment at the NU Haskell Agricultural Laboratory near Concord as part of a team examining fertilizer management through the same program on integrating scientific research and education. Photo by Charles Shapiro, UNL.

The research teams focused on bringing these lessons into the classroom through several collaborative workshops, he added.

> *"The researchers Dave brought together were really the believers and the shakers. A scientist's enthusiasm for his or her own field is simply contagious."*
>
> *– Bonnstetter*

"Actually, through NESEN, we've been doing this for about three years. We're ahead of the nation in living up to these new national standards," said Ron Bonnstetter, UNL professor of education and co-leader of the project. "The researchers Dave brought together were really the believers and the shakers. A scientist's enthusiasm for his or her own field is simply contagious."

Common Misconceptions About Inquiry

1) Inquiry is the sole approach for teaching science.
2) Inquiry = Hands-on.
3) Inquiry teaches science process not content.
4) Inquiry is unstructured (i.e. chaotic).

The Truth About Inquiry

1) Inquiry is not an either/or proposition.
   * Matches teaching approach to learning objectives.
2) Not all hands-on is inquiry; not all inquiry is hands-on.
   * Inquiry involves students:
      a) Raising their own questions;
      b) Planning, designing and conducting their own investigations.
3) No dichotomy between process and content.
   * Inquiry processes and the development of content work in concert.
4) Inquiry teaching is not chaotic – it is carefully choreographed.
   * Inquiry teaching requires a high level of organization, planning and structure by both teacher and student.

– courtesy of the Exploratorium Institute of San Francisco; presented as part of a workshop moderated by Kathy French, education facilitator for the NU State Museum, during the project on Integrating Earth System Science Research and Education (from NESEN web site).

Dave Gosselin (left), NESEN director, and Kathy French, education facilitator with the NU State Museum, discuss inquiry teaching methods at a workshop on Integrating Earth System Science Research and Education this summer. French presented on inquiry-based teaching. NESEN photo.

> *"And the students are more sophisticated now. They don't want to learn it from a book or a canned lab. They want to get out in the creek and collect data."*
>
> *–Gerdes*

Balancing scientific content with process

Balancing scientific content with scientific process is a key to inquiry-based learning, Bonnstetter added, so students and teachers see the content at work.

"Let's face it. You get to see science concepts when you take science courses. But you don't learn how to do science," said Tom Gerdes, an educator at Bishop Neumann High School in Wahoo involved in the invertebrates research. "And the students are more sophisticated now. They don't want to learn it from a book or a canned lab. They want to get out in the creek and collect data."

Mitch Donnelly, a UNL master's student in science education from LaGrande, Ore., said the project allowed him to take field research into the classroom.

"It gave me a chance to use inquiry-based learning on my own. When you go through school, you don't know how science really works, or how ecosystems really function," said Donnelly, also working on the invertebrates project.

Nitrogen cycling and prairie ecosystems

Linda Geisert of Lincoln High School worked on a team looking at nitrogen cycling and prairie ecosystems, with a particular focus on restoration ecology.

The team investigated soil nitrogen availability as it related to changes in vegetation during the course of prairie restoration. They took soil samples from native prairie, from restored prairies of different ages and from farm fields. They then compared nitrogen and other nutrient content, soil moisture and humus among all fields. Besides doing precise laboratory testing, they bought several kinds of inexpensive test kits suitable to a secondary school setting, they said on the NESEN web page.

"The experience was extraordinary in terms of how my background knowledge about the ecology of the prairie was gelling with the field experience. You're able to see how science is done," Geisert said.

Students should collect their own data

Regarding his team's work and the project as a whole, UNL geographer Don Rundquist said, "I believe that students should, as many a psychologist would no doubt say, 'handle their own rats.' I know from my own experience that it is satisfying to generate and collect one's own data and to use those data to address a meaningful research question." Rundquist is also director of the Center for Advanced Land Management Information Technologies, a joint program of CSD and the SNRS.

His experience also shows that students will actually absorb fundamental concepts of a given area of research more easily and more thoroughly when the learning is oriented to making measurements in the field. An important bonus is that they will also enjoy the process of learning, Rundquist said.

Remote sensing effort spawns ingenuity in the face of the unpredictable

A research project making considerable use of the latest in engineering yielded lessons to student and educator that were more subtle, indirect and humanistic, more related to ingenuity and imagination, than those from traditional results, as well as some closely tied to the scientific facts at hand.

So say project mentor Don Rundquist, director of the Center for Advanced Land Management Information Technologies (CALMIT), CALMIT graduate student Colby Free and Lincoln High School science educator Mark Shearer. The team looked at moisture stress in soybeans using close-range remote sensing.

> *"I believe that there is no better way to learn about a subject than by doing field research. The experiences are enlightening. Many of them will be remembered the rest of one's life."*
>
> *– Rundquist*

The group is part of a science-education initiative at the University of Nebraska-Lincoln funded by the National Science Foundation and cosponsored by the Nebraska Earth Science Education Network and UNL Teachers College. Each team consisted of a university researcher, a secondary-level science educator and a science education student at the University of Nebraska or other Nebraska college.

With education student Chris Moon and CALMIT education coordinator Rick Perk, the team looked at close-range remote sensing of moisture stress in soybeans at the University of Nebraska Agricultural Research and Development Center near Mead. They did so using a middle-infrared spectroradiometer – a sensor measuring reflectance of electromagnetic radiation – geared toward detection of leaf water content. But the lessons probably extended beyond the purely technical aspects of such science.

> *Field study no doubt teaches students about science, but perhaps more importantly, it teaches them about life."*
>
> *– Rundquist*

No substitute for field trials

Both Rundquist and Free emphasized that there is no good substitute for field trials, pun intended, and its occasional tribulations, or for the more pervasive and indirect insights gained from encountering the inevitable confounding variables of a natural setting. The patience and ingenuity that come from these encounters with obstacles are often as important as the intended results, they said.

"I believe that there is no better way to learn about a subject than by doing field research," Rundquist said. "The experiences are enlightening. Many of them will be remembered the rest of one's life."

"First and foremost is the exposure to all that is involved in conducting research," Free said. "Compared to the traditional experiments conducted in a controlled setting, this type of experience shows you the real nature of the nuances of research. For example, it is very likely that you will have to adjust your research plans due to unforeseen circumstances, or that you may get results that do not conform to your hypothesis."

Field time most precious

Rundquist said, "The famous geographer Carl Sauer said 'field time is your most precious time.' The aspects of my career that I recall with the greatness fondness are those related to collecting data and discussing research while working in the field. Field study no doubt teaches students about science, but

This platform used in close-range remote sensing allows CALMIT to take measurements without the expense, time constraints and coverage gaps of satellite or airborne imagery. This boom assesses reflectance over a field of corn at the NU Agricultural Research and Development Center at Mead. The NESEN research team used the same technology to examine moisture stress in soybeans. CALMIT photo.

> *"Neither Mark nor I are experts in this field, and when we started we knew almost nothing at all. The responsibility was on us to not only find the answer – least important at first – but to find the questions and then a way to answer them."*
>
> *– Moon*

perhaps more importantly, it teaches them about life."

"Field research involves greater exploration of design, ideas, ingenuity and speculation, rather than (that aimed at) canned results," Free said.

Rundquist's role was to suggest a topic and an approach to exploring it. Perk also assisted in guiding the team through its project, while Free aided Moon and Shearer in preparing the research site, in equipment use and in data collection, processing and interpretation. He also discussed the importance of the research to the agricultural community and reviewed other remote sensing and geographic information systems (GIS) used in agriculture, he added.

Non-imaging close-range remote sensing is often used as a check on satellite or aerial measurements, but it has benefits beyond that, contributing to some of the best student research, Rundquist said.

"Most of the time, the student researcher can't find suitable existing image data to address the problem anyway, and it's usually not feasible to buy aircraft or satellite data for a student project. I have found that, more often than not, the image-oriented projects are difficult to finish," he explained.

Sensor allows data collection in many settings

A close-range field sensor allows students to collect data under full sun, partly cloudy conditions or indoors and do it in time to complete the course requirements, he added. In addition, many of these field instruments are "hyperspectral," meaning they collect data across as many as 100 or more channels of data, allowing one to acquire detailed information about the object of interest, as well as explore nuances of diagnostic reflectance and absorption features, he said.

The project also required a portable greenhouse that allowed the team to prevent moisture from reaching the beans. The infrared sensor allowed them to measure the radiant temperature of the crops relative to the same for the soil, Free said.

Shearer concurred about the value of this kind of learning, much of which can be translated into classroom teaching, he said.

"This project gave me a more realistic view of research, which should allow me to be a more effective bridge between my students and field research," he added.

Able to improvise

Moon was also able to take advantage of the need to improvise.

"Instead of coming up with something that fell into place along with the work of a sponsoring professor – with an already existing methodology – we were in a lot of ways starting from scratch. We would try one method, see it fall apart and then scramble to come up with another method." he said.

Since real science includes such experiences, he and Shearer feel a responsibility to communicate this to their students, Moon explained.

"In the classroom, students are terrified about getting the 'wrong' answer and constantly ask if their solution is acceptable," he said. "What they aren't ready for, and we hope this is something we can change, is being the expert.

"The NESEN project put us in their shoes. Neither Mark nor I are experts in this field, and when we started we knew almost nothing at all. The responsibility was on us to not only find the answer – least important at first – but to find the questions and then a way to answer them," he added.

– by Charles Flowerday, CSD Editor

Drought's a teaching tool in North Platte study of water dynamics

No one ordinarily thinks of drought as a good thing. But it can have some positive effects if you use it as an educational tool.

So says geologist Jim Goeke of the team he led studying groundwater-surface water dynamics and water quality as part of a university project on "Integrating Earth System Science Research and Education." The group is part of a science-education initiative at the University of Nebraska-Lincoln funded by the National Science Foundation and cosponsored by the Nebraska Earth Science Education Network and UNL Teachers College.

Each team consisted of a university researcher, a secondary-level science educator and a science education student at UNL or other Nebraska college. Teams collaborated in studying one issue and devised a research strategy. All the teams then discussed the lessons learned for secondary education. The water team included Kandi McFadden of North Platte High School and Jason Lavely of Hastings College.

"We shared a common interest in water. Kandi had invited the Twin Platte NRD people me and to talk to her class about water. She has some of the new-teacher enthusiasm. Jason is from Sutherland, so he's grown up in the Platte Valley and is familiar with its natural resource issues," Goeke noted.

Drought brings water lessons home

"One of the problems we all struggled with has to do with working with groundwater. Hands-on experiences are difficult. That's where droughts can be used to good advantage. In times of shortage, people are more keenly aware of the water situation," the Conservation and Survey Division scientist said.

In fact, the team found its hands-on experiences by working closely with the Twin Platte Natural Resources District, an organization Goeke regularly assists, and slip-streamed its activities on the NRD's recent, intensive study of groundwater-surface water quantity and quality in the North Platte area. In view of the impact of Nebraska's 1996 conjunctive-use water law, LB108, which allows the state to jointly regulate groundwater and surface water, the Twin Platte NRD initiated its "Transect Project," a series of monitoring wells drilled in a line north and south through North Platte. It also includes stream gauges on the North Platte and South Platte rivers.

Due to the drought, the project has acquired more visibility than it might have otherwise.

Trees and water are good politics

"Trees and water make for good politics," Goeke added. "The media can help you provide an educational opportunity." The UNL groundwater specialist has also received recognition for his involvement in tree planting in the North Platte area.

In cooperation with Glen Bowers, the NRD's water programs coordinator, the team's activities have involved measuring water levels, watching wells being pumped to clear them for sampling, taking water samples for chemical analysis and creating water-level graphs from the measuring. This water-level information was then compared with the flow stages of both rivers for some lessons related to groundwater-surface water interaction. The group also looked at the impact of pumping high-capacity irrigation wells on drawdown near the wells, Goeke said.

It was good year to make a comparison.

Dry summer puts South Platte at low flow

"We've had a very dry summer, so we've seen the South Platte at very low flows, but the North Platte was quite full due to releases from Lake McConaughy for mandated in-stream flows," he explained.

"Kandi has then parlayed this experience into a water-based environmental curriculum at 4-H camp at Halsey," he said.

In addition to the educational impact, the group has worked with NRD personnel in helping North Platte participate in the Groundwater Foundation's Groundwater Guardian program, in which a city promotes awareness of local groundwater issues through a results-oriented activity with an educational impact.

"We sit in the middle of the High Plains aquifer, one the largest sources of groundwater in the country. Water is a lot of the goodness of the good life we talk about in Nebraska," Goeke added. Educationally speaking, even in a drought.

– by Charles Flowerday, CSD Editor

McFadden receives grant from schools foundation for more water education

As an outgrowth of her involvement with the UNL summer workshop on integrating science research and education, Kandi McFadden, a North Platte High School science teacher, has received a grant from the North Platte Public Schools Foundation for further water education work.

The grant of $1,860 will help her continue to use the Twin Platte Natural Resources District's Transect Project as an educational resource with her students. In conjunction with the Groundwater Guardian program of the Lincoln-based national Groundwater Foundation, her classes will use the money to buy sampling kits for water chemistry, water-level measuring and graphing equipment, topographic maps and even materials for building a miniature aquifer and landform model, McFadden said.

"This was a direct outgrowth of the lesson plans developed from the NESEN project," she explained.

During the summer, McFadden was part of a group participating in a research-oriented science-education initiative at the University of Nebraska-Lincoln funded by the National Science Foundation and co-sponsored by the Nebraska Earth Science Education Network and UNL Teachers College (see article above).

"That's the best experience I've had in teacher education, and I hope they continue it for other teachers," she said.

The students are going to build miniature wells in the model aquifer and study soils and water movement, she added. As a final project, they will incorporate some of their learning into a handout that will be distributed to the citizens of North Platte, perhaps through their water bill in conjunction with the Groundwater Foundation.

Fertilizer team learns about research process and bromide tracer

Sometimes science is more about how you get where you're going and less about the destination. Sometimes you learn more about process than product.

But this helps you achieve better results in the future and better communicate to students how one does science.

That's the main lesson from the fertilizer and environmental management team participating in a project on "Integrating Earth System Science Research and Education," according to Charles Shapiro, NU extension soils specialist heading up this team. The group is part of a science-education initiative at the University of Nebraska-Lincoln funded by the National Science Foundation and cosponsored by UNL Teachers College and the Nebraska Earth Science Education Network, a joint program of the Conservation and Survey Division and the School of Natural Resource Sciences.

Each team led by university researcher

Each team consisted of a university researcher, a secondary-level science educator and a science education student at UNL or other Nebraska college. Teams collaborated in studying one issue and devise a research strategy. All the teams then discussed the lessons learned for secondary education.

This team consisted of Shapiro, Janet Oborny of Madison Middle School and UNL student Kristina Nevius of Lincoln. They tackled the problem of nitrogen fertilizer leaching from the crop root zone into water supplies and used a bromide tracer to simulate this leaching.

Working with just a $1,000 of outside funding, the student and educator had to learn enough about experimental design and statistics to be able to investigate a field situation with many unknowns, as opposed to a textbook lab experiment where the desired outcome is known, Shapiro said.

Design plot plan and checks

"They had to come up with a plot plan and design the checks. And they did a literature review. Then they had to work together and come up with an experiment. My role was to keep them from going too far afield," he explained.

One of the major constraints was a four-week turnaround, instead of the whole growing season, he said. With Shapiro's time and his technician's coming for free, the $1,000 went mostly for lab analysis of soil samples taken down to two feet in irrigated corn on a 10-point, three-dimensional grid at the NU Haskell Agricultural Laboratory near Concord.

> *"They had to come up with a plot plan and design the checks. And they did a literature review. Then they had to work together and come up with an experiment. My role was to keep them from going too far afield."*
>
> *– Shapiro*

A colleague of Shapiro's, Bill Kranz, an NU extension irrigation specialist, had done some bromide work in the lab but not in the field. Bromide is a good tracer because it is non-reactive, isn't normally found in crops or soils, isn't taken up into the plant and moves with water.

Nearby corn plants were cut off to prevent plant uptake, and a control group with no treatment was established. Then three treatments consisted of knifing bromide into the soil as one would with nitrogen fertilizer; knifing it in and running over it with a tractor to compact soil and inhibit infiltration of water; and applying the chemical and using a metal plate over the spot as another control, to prevent direct water movement.

The lab work is still coming in, but it looks like they are getting differential results, Shapiro said. The next step will be to draw up a cross section showing patterns of distribution.

Like a master's thesis in four weeks

"It was asking a lot. Essentially, they had a master's thesis in four weeks. We did some thinking about things we didn't do. We might design some better checks in the future," Shapiro said. "Something like this is important for science education, but we could do some things to make it more efficient in the future."

Oborny said the experience was useful in a number of ways.

"The project gave me insight into how to teach scientific inquiry in the classroom. I feel I'm better prepared to teach the content," she said. "My approach will be student-centered, where they make the decisions on how to address various issues, and I am simply their facilitator."

The team developed a sound and complex soil unit in which the students will look at soil composition, permeability, moisture, leaching and its prevention. They'll also examine the best soil for plant growth, she said.

"The biggest thing for me was to learn more about rural culture. I moved up to northeast Nebraska," explained Nevius. "I was working on a farm. It was fun to go out and get dirty. I didn't even know what leaching was before this," she added. "Now I have a basic understanding of soils and agriculture."

– by Charles Flowerday, CSD Editor

Kristina Nevius, UNL education student from Lincoln, and Janet Oborny of Madison Middle School, set up a rain gauge at the NU Haskell Agricultural Laboratory at Concord. With NU extension soils specialist Charles Shapiro, they researched the use of bromide as a tracer for studying nitrogen leaching from the crop root zone. Photo by Charles Shapiro, UNL.

National Science Foundation and Toyota education grant proposals spin out of research

Work on Chinchorro may revamp notions of tribe's diet, culture

Perhaps the most far-reaching results from the research teams in a recent University of Nebraska-Lincoln project on Earth science research and education has come from the one investigating an ancient culture of Chilean Indians.

The first has been data so promising in its challenge to conventional wisdom that the team will submit a $75,000 proposal to the National Science Foundation for future work. The second involves another proposal to a Toyota education fund for travel money to send two or three secondary students to Chile to help with the investigation, according to the team leader and its science educator.

The group is part of a joint project of the UNL Nebraska Earth Science Education Network (NESEN) and Teachers College funded by the National Science Foundation. Each team consisted of a university researcher, a secondary-level science educator and a science education student at UNL or other Nebraska college. Teams collaborated in studying one issue and devised a research strategy. All the teams then discussed the lessons learned for secondary education. NESEN is a joint program of the Conservation and Survey Division and the School of Natural Resource Sciences (SNRS).

> *"The Chinchorro also have been viewed as practicing a basic kind of subsistence strategy that later gave rise to more complex cultures along the Andean coast."*
>
> *– Reinhard*

Karl Reinhard, anthropologist with the SNRS, led a team looking into the diet and environment of the Chinchorro Indians.

Karl Reinhard (left), UNL anthropologist with the School of Natural Resource Sciences, Sara Leroy-Toren, of the Lincoln Public Schools Science Focus Program at the Children's Zoo, and Melanie Olson, a UNL education graduate student, examined the diet and culture of an ancient tribe of Chilean Indians known as the Chinchorro. NESEN photo.

It also included Sara Leroy-Toren, a science educator at the Lincoln Public Schools Science Focus Program located at the Children's Zoo and known as "The Zoo School," and Melanie Olson, a UNL graduate student in education.

Chinchorro lived 9,500 years ago

"The Chinchorro lived between 9,500 and 3,500 years ago near the coast and represent the earliest culture known to practice mummification. They also have been viewed as practicing a basic kind of subsistence strategy that later gave rise to more complex cultures along the Andean coast," Reinhard said.

> *"They will come back, and we'll teach them to process the results, teach them what they've got. Then they will teach other students at the school."*
>
> *– Leroy-Toren*

The researchers investigated their diet and ecological adaptation by analyzing microscopic and larger fossils from the intestinal contents of 27 Chinchorro mummies from the last phase of the culture. By identifying the fossils, they were able to determine what foods were eaten in the last days before death. Also, microfossils such as pollen helped reveal what the climate and environment was like when the mummies were made, he said.

An important aspect of this research is that Andean cultures don't have the same opposition to scientific study of Indian remains that has been voiced in this country, said Reinhard, who has been involved with the study and repatriation of Omaha tribal remains in Nebraska. He has also been promoting a radiometric scanning technique for studying contents of mummies without dissection, he explained.

Contents delivered through Chilean scientist

The contents were delivered through a fellow scientist at the University of Nevada-Las Vegas, Bernardo Arriaza, a native Chilean. The Chinchorro apparently did not rely mostly on ocean- or land-based animals nor on desert plants as much as was previously thought. Instead, they ate a good deal of swamp plant foods, Reinhard explained. The supposed marine exploitation was thought to have provided the Chinchorro with an adaptation stable enough that it allowed for cultural elaboration, social stratification and conflict and a religious system that included mummification.

This new dietary evidence may yield insights into this culture that may change other ideas about the Chinchorro, Reinhard said. Of particular interest in the next phase of research will be a chemical analysis of bone tissue. Prior to about 4,000 years ago, mummies were gutted, so no data from the intestinal tract is possible. By looking at bone chemical data, the researchers hope to compare chemical signals of diet from older mummies with later ones from the same cemetery. They also propose to collect reference plant specimens from the nearby Atacama Desert.

Group seeking Toyota teachers grant

In addition to the NSF proposal, the group will submit a $10,000 proposal to the Toyota Tapestry Teachers Grant, a fund that supports math and science teaching, said Leroy-Toren.

If funded, the money will allow the group to take a few Zoo School students to Chile to do some hands-on collecting of plants and sediments, she said.

"They will come back, and we'll teach them to process the results, teach them what they've got. Then they will teach other students at the school," Leroy-Toren said. The Zoo School stresses a community of learners teaching model in which learners identify an expertise, acquire it and then teach others.

Olson said she learned better how to use university scientists as resources and developed a good deal of enthusiasm for botany and ecology.

This scene shows a Chinchorro village near the coastline. © Photo from the Museum of Archaeology, Universidad de Tarapaca, Chile, by Philippe Plailly, courtesy of Eurelios.

"It was a exciting way to learn and understand the fundamentals of a science research program," Leroy-Toren said. "We were asked to do real work. And I knew some things that were a contribution. It became an outlet and a synthesis."

– by Charles Flowerday, CSD Editor

Land evaluation text takes holistic teaching tack for variety of venues

A new land evaluation text for secondary education soon to be published by the Conservation and Survey Division will feature more in-depth discussions than most traditional soil judging manuals.

It will also include topics not often found in such manuals, such as discussions of water-holding capacity, soil chemical reactions, soil horizon samples and new diagrams and photos, according to Francis Belohlavy, University of Nebraska-Lincoln soil scientist with CSD.

The manual, intended for the traditional soil judging contests once sponsored jointly by Cooperative Extension's 4-H program and Future Farmers of America, has been renamed "Fundamentals of Land Evaluation in Nebraska – Judging Soil and Land" to better communicate a holistic approach to such classification. The contest is no longer cosponsored by 4-H but continues to receive FFA support.

"This new manual is really a springboard into the soils and geology of Nebraska," he added.

The older manuals were used mostly in vocational agriculture curriculum, but this manual also will be used by many earth science classes in secondary education. There is as yet no contest for earth science classes at the national level, but a state competition has been proposed, Belohlavy explained.

The statewide land evaluation contest, traditionally held in the fall, usually involves about 600-700 students in regional competitions and 100-130 in the finals. The national contest is held in the spring at Oklahoma City, Okla.

Helping shape the contest since 1973, Belohlavy wrote the manual to make it more understandable than previous such texts. It is written so it can be used in everything from eighth-grade earth science to high school vocational agriculture, he said.

Urban students interested in earth science are increasingly interested in soils and landscape subjects, he said, and a building-site evaluation section will be added. Besides teaching how to classify land according to vulnerability to erosion and suitability for various crops or other vegetation, the manual teaches students about the environment in general and our obligation to protect it, he said.

Students participate in a collegiate soil judging contest in Otoe County in October 1994. The student to the far left works with a Munsell color chart to identify soil color. The soil profiles being exposed in the rear are not part of the secondary level competition. Photo by Jim Culver, U.S. Natural Resources Conservation Service.

Wet basements during or right after a drought? It's possible!

Probably the last thing a homeowner is thinking about during a drought is a wet basement. And while some rain and snow brought much of Nebraska closer to normal precipitation, some of the southeastern part of the state is still considered in a serious drought, and most experts are pointing to a possible multiple-year cycle of dimished precipiation.

Recent rains haven't been enough to cause problems, explained Mark Kuzila, director and head soil scientist with the University of Nebraska Conservation and Survey Division. But if more substantial downpours occur, particularly in the spring, some basements could become wet or flooded, especially those in fine-grained sediment.

How is this possible?

"Many soils in Nebraska, especially those in the eastern part, contain clay that shrinks when it's dry and swells when it's wet. Dry weather causes the soil to pull away from the foundation and makes cracks form near it," Kuzila said.

These gaps provide small channels for water to flow through, which can then easily enter a basement through cracks or utility holes in the foundation, he added.

What's a homeowner to do?

First, don't fill the gap between the soil and the foundation with more soil. That won't allow room for expanding soil when it gets wet. Once wet, its expansion could cause damage to the foundation, possibly creating cracks that will compound the problem, he said.

Instead, during dry periods, apply light to moderate amounts of water to the soil near the foundation to prevent cracks from forming.

Although it's a task that's easy to ignore during dry weather, now is also a good time to clean out gutters, because drought can cause leaves to fall earlier than normal, Kuzila explained. Clean gutters help channel water away from the building.

For further assistance in determining the cause of water in basements or general information about soils conditions, contact the Conservation and Survey Division at (402) 472-7537; Room 113, Nebraska Hall, University of Nebraska, Lincoln, NE 68588-0517; or e-mail: bmartin1@unl.edu.

Geospatial data mining aids decision-making for public, private users

Second year of multi-disciplinary research focuses on crop, natural hazards

by Charles Flowerday
CSD Editor

A multi-disciplinary, data-mining research project at the University of Nebraska-Lincoln aimed at decision support has produced substantial tools to help farmers and communities address cropping concerns, natural hazards and natural resources over the past year and promises more of the same soon.

A collaboration of the UNL Department of Computer Science and Engineering (CSE) and Center for Advanced Land Management Information Technologies (CALMIT), this decision support research takes a wide array of resources available through information technology, particularly remote sensing and geographic information systems (GIS), and trains these on real-world problems facing farmers, rural communities and urban areas. Called "Geospatial Decision Support Systems" and funded by the Nebraska Research Initiative (NRI), it also includes agronomy, natural resources and engineering faculty at UNL and the University of Nebraska at Omaha (UNO).

A crop planting guide and a drought monitoring initiative have emerged as two of the more substantial contributions of the past year, explained Bill Waltman, research coordinator for the NRI project. Waltman is an agronomist funded through UNL's Department of Computer Science and Engineering who has received in-kind support of office space and computing facilities from CALMIT, a joint program of the Conservation and Survey Division and the School of Natural Resource Sciences.

Other projects bearing fruit are related to floodplain and habitat mapping; mapping of natural hazards such as hail and lightning; applications in computer-assisted agriculture; and conservation planning and natural resource management. Another milestone involved cosponsoring the Geospatial Forum last March in Kearney, which brought together more than 60 agribusiness and natural resource managers, crop consultants and university faculty to discuss web-based, decision-support systems. The University of Nebraska at Kearney (UNK) and Marc Albrecht of the UNK biology department, in particular, were also instrumental to the success of the forum, explained Steve Reichenbach, chair of the UNL Department of Computer Science and Engineering and the project's principal investigator.

> *"You can test various scenarios that assess the risk of frost or the probability of accumulating enough heat units for a given corn hybrid planted on a certain date."*
>
> *–Waltman*

More mature projects on natural and crop hazards

"Some of the more mature projects in the initiative have to do with natural hazards, particularly drought monitoring and hail," Reichenbach said. "And one of things I've been more personally involved with has been the development of the planting guide for corn hybrids."

The guide is an on-line resource that allows farmers to use web-based information in the selection of hybrids, planting dates and potential heat. It uses geographic data and the quantification of risk in providing information about a given vicinity.

This web page from the planting date guide created by the NRI decision support project shows calculators of growing-degree days (heat units) and frost-free periods for corn and soybeans. NRI image.

The planting date guide was developed in conjunction with the J.C. Robinson Seed Company, generally known as Golden Harvest, of Waterloo, Neb., and is the first polished product from this research. It should be a prototype for other such companies.

Data on frost-free periods and growing-degree days

Working with Jeff Peake of UNO's geology and geography department, Gautam Jindal, a CSE graduate student, and agronomists from UNL and industry, Waltman and Reichenbach have devised a tool that allows farmers and crop advisors to acquire data on frost-free periods and growing-degree days (heat units) specific to a given field. It draws on data bases such as CALMIT's land-cover mosaic created from satellite imagery, digital aerial photography from the state Department of Natural Resources and a climatic decision support tool developed by Steve Meyer of the SNRS.

"You can test various scenarios that assess the risk of frost or the probability of accumulating enough heat units for a given corn hybrid planted on a certain date," Waltman explained.

In the future, enhancements to the guide will also incorporate digitized soil survey data on soil quality and water-holding capacity to assess the drought tolerance of a given field, he said.

Another effort with Golden Harvest has involved using new geospatial tools to monitor seed-production fields. Waltman, Reichenbach and former CALMIT geographer Marcus Tooze, along with H. R. Sinclair of the USDA Natural Resources Conservation Service and Golden Harvest agronomists, combined digital soil survey interpretations with seed production data to determine drought tolerance and other factors related to soil quality, water-holding capacity and yield prediction.

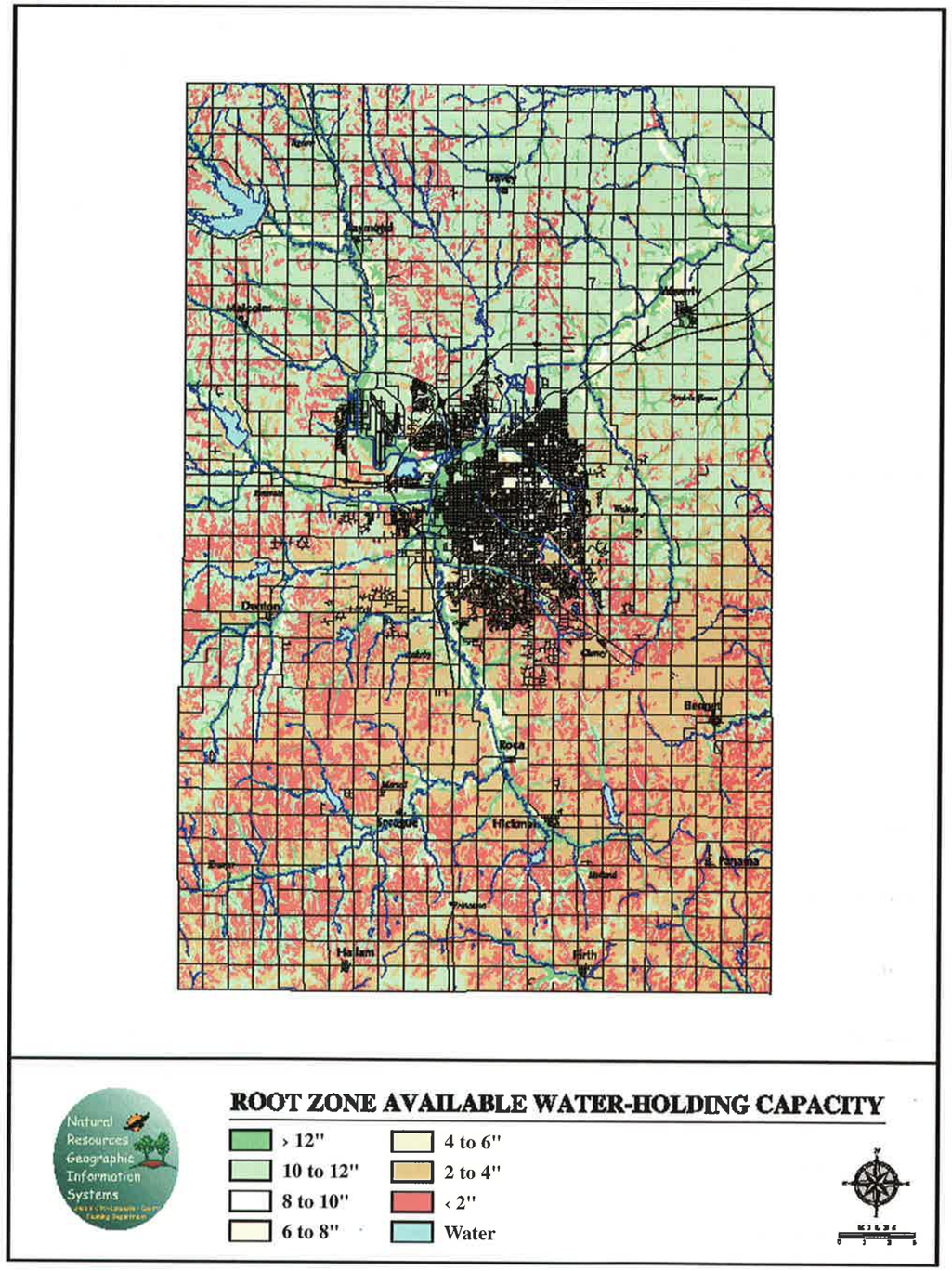
Timely, local web-based drought index

In addition, with a drought looming as a threat that may span several years, the decision support team will be working this year on developing a web-based drought index that delivers data faster than the current one-month time lag and more locally than the regional coverage of the present monitor. The project has submitted a proposal to the National Science Foundation in cooperation with Don Wilhite of the NU National Drought Mitigation Center (NDMC) and the USDA Risk Management Agency. An important source of information on moisture stress, the NDMC's Drought Monitor web page has been reproduced in the mass media all over the country. But the demand for more timely and more site-specific drought data prompted the proposal, Waltman said.

"You should be able to pull up a community like Wahoo or Valentine and get timely drought information. Also, the state and federal agencies need quicker and more detailed information for mitigation and emergency response," Waltman explained.

Dovetails with CALMIT's ag-related remote sensing

Dovetailing with CALMIT's agricultural remote sensing program, NRI-funded projects supervised by CALMIT Director Don



The Root Zone Available Water Holding Capacity (RZWHC) of soils in Lancaster County, Nebraska, was derived from the Soil Ratings for Plant Growth and the Soil Survey Geographic Database (Sinclair and others, 1995, 1999). The available water-holding capacity was calculated across an effective rooting depth. A soil with less than 8 inches of RZWHC will be drought vulnerable in low rainfall years. Soils with greater than 8 inches of RZWHC will be buffered during drought events. NRI image.

Rundquist have focused on monitoring moisture stress and hail damage in crops with close-range, aerial and satellite sensors across varying time frames and spatial scales. Geography graduate student Weirong Chen continues work begun more than a year ago on integrating data across different spatial and spectral resolutions of electro-magnetic reflectance.

"Regarding the moisture stress component, we've intended to do work along these lines for a number of years but we haven't had the right equipment. Now we have a system purchased a year or so ago that uses the middle infrared part of the spectrum and allows us to detect leaf-water content," Rundquist said.

A pilot effort this summer linked with a project on integrating scientific research and education sponsored by the Nebraska Earth Science Education Network (see related story on p. 3) involved Rundquist, CALMIT graduate student Colby Free, Lincoln High School science teacher Mark Shearer, and UNL Teachers College student Chris Moon. In conjunction with CALMIT education coordinator Rick Perk, it looked at remote sensing of moisture stress in soybeans.

CALMIT also has been doing hail-damage research tied to NASA's Commercial Remote Sensing Program (see related story on p. 15) that involves IGF Insurance, an Iowa crop insurance company. The project investigated use of remote sensing to quantify hail damage and has been reasonably successful, he said.

Other CALMIT developments

Other CALMIT developments relevant to geospatial decision support come from the Gap Analysis Project (GAP), a cooperative venture of the U.S. Geological Survey's Biological Resources Division and a host of state, local and nonprofit organizations (see related story on p. 19). While GAP seeks to determine the extent to which all native plant and animal species are represented in the present mix of conservation lands, its detailed land-cover data also has important applications to a variety of decision support systems for habitat management statewide, according to GAP co-principal investigator and CALMIT Associate Director Jim Merchant.

Crop-type mapping as part of the Platte River and Basin Cooperative Hydrology Study (COHYST; see related story on p. 27) also has been fundamental to agricultural decision support; lake classification work has contributed to water resources management; and base line land-cover data are crucial to understanding environmental change in protected land-based ecosystems and water and agricultural environments, Merchant explained.

Other land-cover spinoffs include work by CALMIT geoscientist Patti Dappen, who has been using Polk County data on soils and land-use changes to assist management of wetlands in the Rainwater Basin of south-central Nebraska, and an inventory of center-pivot irrigation systems from COHYST that has contributed to drought-mitigation decision support, Waltman said.

Natural resources assessment of woodlands

One project supervised by CALMIT geographer Sunil Narumalani, also a professor in the School of Natural Resource Sciences, has been a natural resource assessment of riparian (river-related) woodlands in Polk County. Performed by geography graduate student Abu Gadem and part of the COHYST study, it integrated riparian habitat, soil quality and erosion data into a GIS to target areas needing NRCS conservation treatment plans. Gadem's master's thesis work also resulted in an innovation long anticipated but not achieved until recently: digital conservation plans. Polk County should be a prototype for the rest of the state, Waltman said

"They were not able to do that in the NRCS for many years. They've wanted to use digital conservation plans but hadn't gotten those tools developed. Abu was able to make that leap," Waltman said.

> *"You should be able to pull up a community like Wahoo or Valentine and get timely drought information. Also, the state and federal agencies need quicker and more detailed information for mitigation and emergency response."*
>
> *–Waltman*

In addition, Narumalani continues work in the southeastern corner of the Black Hills using satellite imagery to detect vegetation change under varying moisture conditions across ecological zones ranging from grassland to forest and the transition between them. This work should aid in understanding climate and environmental change, Waltman said.

Another application of GAP land-cover data has been in mapping lands of public ownership, which assist natural resource managers as officials examine impacts of neighboring land uses from private land nearby, and in helping organizations like the Nature Conservancy to target its land-acquisition efforts. In addition, public land managers need data on drought that can be gleaned from land-cover information, he said.

Other NRI initiatives

Other NRI decision-support initiatives led by people outside of CALMIT are as follows:

– Scott Gardner, curator of parasitology at the NU State Museum, Ashok Samal of CSE, and Marcus Tooze, formerly of CALMIT, have been working with the NU Medical Center to use a GIS to model, track and analyze disease carriers and potential environments for the hanta virus, carried by mice, and Lyme disease, borne by deer ticks;

– The Lincoln-Lancaster County Planning Office has been using floodplain mapping stemming from NRI-funded soil quality data, particularly that on water-holding capacity and shrink-swell potential, to better manage development by directing it toward lower quality soils not as vital to agriculture;

– Lightning-strike mapping by a master's student working under Peake, Stephen Harmon, has found no significant relationship between strikes and higher terrain or power corridors. Peake has also supervised students looking at hail distribution and drought indexes for possible use by crop insurance firms.

– Sharad Seth and Ashok Samal of CSE, with George Nagy of Rensselaer Polytechnic Institute, continue to work on efficient ways to extract geographic data from hard-copy maps and devise query mechanisms for features such as roads, bridges, streams or buildings.

– Peter Revesz of CSE is continuing to develop sophisticated query and constraint features, as well as animation techniques for climatic data.

Data from web camera, satellite and aircraft also may help high school teaching

America's Farm delivers farm facts for teacher training via the Internet

An experiment in agricultural learning and Internet education is bringing real-time data on farm operations into higher education and will begin to do the same with a Nebraska high school in the near future. It was taught as a pilot college class during the spring and has been incorporated into a nationwide Internet-based curriculum this fall.

Called "America's Farm," this NASA-funded project is a collaboration between the University of Nebraska-Lincoln's Center for Advanced Land Management Information Technologies (CALMIT) and the Office of Internet Studies at the University of Nebraska at Omaha. The result of a $700,000, three-year grant, it features web-camera video and views of the farm from aircraft and satellites.

"The idea is to give students and teachers access to a real, working Midwestern farm and to deliver various kinds of data in a package that teachers can use, all over the web."

– Rundquist

"The idea is to give students and teachers access to a real, working Midwestern farm and to deliver various kinds of data in a package that teachers can use, all over the web," explained Don Rundquist, director of CALMIT, a joint program of the Conservation and Survey Division and the School of Natural Resource Sciences that is UNL's center for remote sensing and geographic information systems (GIS).

Delivered through UNO College of Education

Delivered through the UNO College of Education, the class has been used by educators teaching every age from kindergarten to high school in classes that range from science to social studies to vocational agriculture, said Paul Clark, the UNO college's grant coordinator.

America' s Farm is located on the University of Nebraska's 9,500-acre Agricultural Research and Development Center near Mead, where CALMIT already conducts much of its research on remote sensing, GIS and agriculture. Remote sensing means ways of assessing earth conditions from a distance, and GIS are computerized means of analyzing spatial data.

The course should eventually be cross-listed through UNL and is part of a new inquiry-based format designed to use multidisciplinary intelligence to address open-ended questions, said Rick Perk, CALMIT education coordinator. The problem-based learning scenarios require that students research a problem, develop questioning skills, acquire and analyze data and generate a set of conclusions.

America's Farm also has resulted in a plan to incorporate the nation's first technology track into the curriculum at Mead High School, one of a select group of magnet schools for agriculture in the country. The track would allow students to specialize in high technology such as remote sensing and GIS, Perk added.

First ag magnet school with technology track

"There are about a half dozen agriculture magnet schools across the country, but none has a technology track," Perk said. "The technology track is going to make this truly unique. We are going to introduce the concepts of remote sensing and GIS through the magnet school and through America's Farm."

"One of the things that's been valuable is how the program has evolved," Clark said. "It was first produced as one of the products for NASA, but it evolved week by week in the spring. Then we interviewed the teachers after the semester and redesigned it based on their input."

The variety of uses was one of the main reasons UNO's Internet studies office and CALMIT kept customizing it, Clark explained, a process that will continue.

"As (Rick) Perk has developed additions, we've incorporated them," he said. "We've learned a lot about a high-tech, image-based course. We've been able to develop things we couldn't actually deliver in a course that wasn't on-line."

One of only seven proposals funded out of 180

America's Farm was one of only seven proposals funded out of 180 submitted to the NASA LEARNERS grant program in 1999, Rundquist explained. LEARNERS stands for Leading Educators to Applications, Research and NASA-related Educational Resources in Science and is designed to make a wealth of NASA space data available to educators. Web-based course modules will use the farm's fields and growing conditions in problem-solving learning, he added.

In general, Perk said, America's Farm was created for a variety of reasons: to educate a public relatively uninformed about farming whose children tend to be curious about farms; to take advantage of a recent emphasis on computer-assisted, site-specific farming known as "precision" agriculture; to explore advances in remote sensing, GIS and global positioning systems (GPS) – means of using satellite technology to determine exact location; to augment the teaching of vocational agriculture; to educate producers and farm managers; and to explore practical applications of remote sensing.

The web delivery of information will include: background information about farming, remote sensing, GIS, GPS and mapping; views of farms and their surroundings from the ground level, the air and satellites; data collected and integrated from the field, the air or satellites; educational materials in the form of modules and problem-based scenarios; and technical assistance.

– by Charles Flowerday, CSD Editor

UNL center helps firm track carbon-storing tillage, contain greenhouse gases

A University of Nebraska-Lincoln center is working with an Iowa company that's helping farmers sell carbon storage credits to utilities and other companies in exchange for agreeing to use farming practices that boost the amount of carbon stored in crop residue and soil.

Paying farmers to store carbon is being explored as part of an emerging global effort to reduce atmospheric concentrations of carbon dioxide, a major greenhouse gas associated with global warming. Storing carbon in soil isn't the whole solution to limiting greenhouse gases but could be a key component.

Companies pay farmers to store carbon in exchange for carbon emission reduction credits in accord with the Kyoto Protocol for greenhouse gas reduction. In 1997 in Kyoto, Japan, nations attending a United Nations convention on climate change agreed to guidelines for reducing greenhouse gas emissions.

Named after carbon sequestration

CQuest Ltd. of Des Moines, named after the carbon sequestration it markets, signed an agreement earlier this year with the Affiliated Research Center of UNL's Center for Advanced Land Management Information Technologies (CALMIT) to develop ways to remotely check fields for practices that enhance carbon storage. They're working with NASA on the project, said Al Peters, an NU earth scientist who heads the research center.

CQuest trades carbon emission reduction credits by arranging contracts with farmers who use reduced tillage practices that increase the amount of stored carbon. The company takes about half the payment as a fee, said Greg Lewis, CQuest's president. A typical annual payment to the farmer on an acre of prime farmland would be about $0.50 to $1 per acre of net additional carbon storage on cropland with at least 30 percent residue cover. The price should increase as verification improves, he added.

Verifying conservation tillage practices on foot is labor-intensive and expensive. Instead, CQuest wants to use satellite imagery. NASA also is testing software that can help identify tillage practices in a given image, Peters explained. The project is nearing completion and has been successful in reducing verification costs, Lewis said.

Acquire image before planting

"If we can acquire the image before planting, say, at the end of April, we can determine what farmers have used in the way of tillage practices," he said.

Carbon sequestration has become increasingly important as industries and governments collaborate to reduce greenhouse gases. A carbon emission reduction credit is defined as the equivalent of the warming effect of a metric ton of carbon dioxide removed from or not added to the atmosphere, CQuest literature said.

The company has sold some 20 million tons of emission credits to date worldwide. It expects global trading of all such credits this year to total 100 million tons, according to Environmental Finance magazine and emissions marketing organizations. The credits are not an actual commodity, so the sales system depends on the data's accuracy, Peters said.

"If we can acquire the image before planting, say, at the end of April, we can determine what farmers have used in the way of tillage practices."

– Peters

NASA grant created center two years ago

A $600,000 NASA grant created the university research center two years ago to develop commercial applications of remote sensing and related technologies for the Great Plains. This program offers companies low-risk opportunities to find applications for remote sensing — satellite and aerial imagery — and related technologies, especially in computerized geographic in-

Researchers simulate hail damage on soybeans as part of a project trying to economize the verification of hail loss through remote sensing. CALMIT/ARC photo.

formation systems. Projects typically tackle one or two issues and run six to nine months.

Helps settle hail damage claims

The use of remote sensing to help settle crop insurance claims, in this case from hail damage, has been one of the most successful applications so far, Peters said. The ARC has been working with the National Crop Insurance Service, a private service running a hail-claim school for insurance adjusters, and IGF Insurance of Iowa to remotely assess patterns of hail damage. NCIS is working with a number of hail insurance companies to help them save time and money handling claims.

"Previously, hail-loss assessment was (more) labor-intensive, subjective and error-prone," Peters said.

The adjuster had to walk the field, sample damaged areas and determine loss area. While ground surveys are still needed, with a remote-sensing image, plots can be isolated precisely and then studied from the ground without false starts and with minimal trampling of crops getting to the right part of the field.

Another current project works with two Iowa companies to improve white corn genetics related to protein content. Remote sensing is used to detect water or nitrogen deficiencies in corn. In the last of four 1999 projects completed this spring, Golden Harvest, a seed company in Waterloo, Neb., sought help creating a digital map of agricultural ecology zones and vegetative conditions linked to an interactive, web-based tool to support cropping choices.

During the center's first year projects were completed with three agronomic businesses and one oil and gas firm. Until recently, these technologies have been used almost exclusively by government and university scientists. Many private companies are interested in them but steep start-up and training costs were obstacles.

CALMIT is a joint program of UNL's Conservation and Survey Division and School of Natural Resources Sciences.

– by Charles Flowerday, CSD Editor

CALMIT completes natural resources inventory for state Army National Guard

The Center for Advanced Land Management Information Technologies (CALMIT) of the University of Nebraska-Lincoln has completed a natural resources inventory being conducted for the Nebraska Army National Guard. The work is part of the fulfillment of the Integrated Natural Resources Management Plan (INRMP) the Guard is implementing.

The U.S. Department of Defense (DOD) has called for such plans for all DOD facilities greater than 500 acres, explained Jill Maeder, a CALMIT graduate student in geography working on the inventory. The plan serves to integrate management of natural resources into the rest of the Guard's mission and to promote an ethic of sustainability, both for the public and for those who use the facilities, the Guard has said.

The inventory includes a survey of plant and animal life on Guard training sites near Mead and Hastings and at Camp Ashland near Ashland. Working under their project coordinator, UNL professor and research geographer Sunil Narumalani of the School of Natural Resource Sciences and CALMIT, graduate students and scientists finished field surveys last summer. The report will be completed by spring 2001. Joe Mason, CSD research geologist, is co-principal investigator on the project.

Related project to compile GIS for sites

A second, closely related project involves compiling a package of geographic information systems for the training site lands that includes maps of resources such as climate, soils, and geology. The coverage also involves a relief map of all three sites.

"The GIS layers will match up with the rest of the document and make it more useful for present and future resource management," Maeder said.

Some of the resource issues confronting the Guard at these sites have been soil compaction due to use of military vehicles; wildlife management — hunting of deer was allowed for the first time at Ashland this year; and soil and streambank erosion at Mead due to vehicular traffic, said Markus Craig, CALMIT's GIS coordinator for the Guard project and a UNL graduate student in community and regional planning.

Wetlands also concern

Another concern has been wetlands management and mitigation, Craig said. After the Army Corps of Engineers had identified wetlands, the Guard worked with the Boy Scouts to build mitigating wetlands along a tributary to Clear Creek at the Mead site. Another project with the Scouts involved assembling and distributing nesting boxes for wood ducks, he added.

Researchers collected data for the plant and animal inventories this summer using a global positioning system and line transect surveys, explained Milda Vaitkus, a CALMIT resource specialist. Amanda Holland, a CALMIT resource specialist, has also worked on the habitat inventories, Vaitkus said.

CALMIT is a joint program of the Conservation and Survey Division and the UNL School of Natural Resource Sciences.

Digital elevation model can be used in relief, watershed, land-cover maps

The Earth Science Information Center (ESIC) of the Conservation and Survey Division (CSD) has a new elevation data set for the state that can be used to produce shaded relief maps, drainage networks and watershed definitions, among other products.

Other applications are in land-cover maps, correcting remote sensing data and determining landform characteristics such as slope and aspect, the direction a slope faces.

The data set, generally called a digital elevation model (DEM) and taken from the new National Elevation Dataset of the U.S. Geological Survey, will be available by county through the Internet and on compact disk (CD). ESIC, a unit of the University of Nebraska-Lincoln's CSD that serves as the state distributor for all federal geospatial data on Nebraska, is releasing the data set. It was purchased jointly by CSD – the state geological, water and soils survey – and the Center for Advanced Land Management Information Technologies (CALMIT), explained Les Howard, CSD geographic information systems specialist. CALMIT is a joint program of CSD and the UNL School of Natural Resource Sciences.

A shaded relief map produced by the new digital elevation model acquired by CALMIT and available through the CSD Earth Science Information Center. CALMIT image.

"We found that format needs vary considerably, but we tried to take a majority-rules approach and made it consistent with other data sets available through ESIC and other outlets, like the digital topographic maps and digital orthophoto quads," Howard said.

This means that the type of projection and base line elevation datum are the same and that they can be combined with these other data sets, he explained.

Anomalies and edge-matching problems have been eliminated in this DEM, and plans are to provide the data in a seamless statewide coverage on a pair of CDs, Howard added. The data can also be broken down by natural resources district, by watersheds or drainage basins or by combinations of counties that comprise regions, he said. A nominal fee will be charged for data available on a CD. For more information, contact Les Howard at (402) 472-9192 or by e-mail at lhoward3@unl.edu.

New reprints from the Conservation and Survey Division — for 1999-2000

Geology

RS-273 **The Nebraska Earth Science Education Network Electronic Communication Project**, *in* Journal of Geoscience Education, v. 47, 1999: Gosselin, D.C., Feurer, R., Frack, S., Musson, A., Mayo, L, Karel, C., Schafer, E., Snyder, C., Sarchett, J.,Alfieri, M.L.- $1.50

RS-274 **Tectonic Implications and Influence of the Midcontinent Rift System in Nebraska and Adjoining Areas**, *in* Basement Tectonics (R.W. Ojakangas and others, eds., 1995): Carlson, M.P. - $1.50

RS-275 **New Data and Interpretations for the Precambrian, Midcontinent USA**, *in* Basement Tectonics (Sinha, A.K., ed., 1999): Carlson, M.P. - $1.50

RS-276 **Transcontinental Arch — A Pattern Formed by Rejuvenation of Local Features Across Central North America**, *in* Tectonophysics, 305, 1999: Carlson, M.P. - $1.50

RS-283 **Marine Fossils from Permian Redbeds (Satanka Shale) at Laramie, Wyoming**, *in* Contributions to Geology (Univ. of Wyo.), v. 31, no. 2, May 1997: Chen , X-H. & Boyd, D.W.: $1.50

RS-285 **Earth in Four Dimensions — Development of the Ideas of Geologic Time and History,** *in* Nebraska History, Fall 1999: Diffendal, R.F., Jr. - $1.50.

Water

RS-272 **Fluoride in Nebraska's Ground Water**, *in* Ground Water Mont. & Remed., spring 1999: D. C. Gosselin, Headrick, J., Harvey, F. E., Tremblay, R., McFarland, K. - $1.50

RS-277 **Evaluation of Two Methods for Determining Soil Gas Permeabilities from Pneumatic Tests,** *in* Environmental Geosciences, v. 4, no. 2, 1997: Chen, X-H. - $1.50

RS-278 **Utilization of the Hantush Solution for the Simultaneous Determination of Aquifer Parameters**, *in* Ground Water, v. 35, no. 5, Sept.-Oct. 1997: Chen, X-H. & Ayers, J.F. - $1.50

RS-279 **Aquifer Properties Determined from Two Analytical Solutions**, *in* Ground Water, v. 36, no. 5, Sept.-Oct. 1998: Chen, X-H. & Ayers, J.F. - $1.50

RS-280 **Analysis of Nitrate-Nitrogen Movement Near High-Capacity Irrigation Wells**, *in* Ground Water Mont. & Remed., fall 1998: Chen, X-H., Ayers, J.F. & Gosselin, D.C. - $1.50

RS-281 **Determination of Unconfined Aquifer Hydraulic Properties from Recovery Test Data**, *in* Jour. of the Amer. Water Res. Assoc., v. 35, no. 4, Aug. 1999: Chen, X-H. - $1.50

RS-282 **On the Use of Semi-Logarithmic Plots for Baseflow Separation**, *in* Ground Water, v. 37, no. 5, Sept.-Oct. 1999: Szilagyi, J.: $1.50

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State GIS Symposium to highlight local applications in Lincoln this spring

Nebraska GIS/LIS Association plans symposium, fosters adoption of GIS at state, local levels

The Nebraska GIS Symposium will emphasize applications of geographic information systems (GIS) in city and county government and feature speakers, short courses and exhibits.

To be held May 8-10 at the Cornhusker Hotel in Lincoln, it will be preceded by a NASA remote sensing-satellite imagery workshop. The symposium itself will include short courses on global positioning systems, GIS software, digital topographic maps and evaluating GIS consultants. Richard Allen of Cincinnati will be the keynote speaker. He will talk about why the Cincinnati GIS program is succeeding, including strategies that any local government can employ, said Scott Richert, president of the Nebraska GIS/LIS (Land Information Systems) Association, which led the planning for the conference.

The purpose of the NASA workshop is to help state and local government offices better understand how remote sensing can support their programs and policies, Richert said. Held the day before the symposium, the workshop is sponsored by the Nebraska GIS/LIS Association in conjunction with the University of Nebraska-Lincoln Center for Advanced Land Management Information Technologies (CALMIT) and the Western Governors' Association. CALMIT is a joint program of the UNL Conservation and Survey Division and the School of Natural Resources.

Also working with real estate appraiser board

The association is also working with the Nebraska Real Estate Appraiser Board to allow assessors and appraisers to acquire education credits for the symposium's training workshop in ArcView, an important GIS software, Richert said.

"Another thing that's worth noting is the formation of an education subcommittee. We've talked about emphasizing the education of both K-12 and GIS professionals," said Jim Lacy, treasurer of the GIS/LIS association and CALMIT's information technology manager.

Those interested should contact David Smith, assistant extension GIS specialist with the Lancaster County extension office, chair of that subcommittee, he added. Smith's office is 444 Cherry Creek Road, Lincoln, Neb., 68528-1507; his phone is (402) 441-7180.

The Nebraska GIS/LIS Association has largely taken over the planning of the conference from the state GIS Steering Committee, Lacy said. Both are committed to fostering communication among public- and private-sector GIS users, GIS companies and geospatial data organizations; updates on GIS applications; and assessing the status of GIS use.

Cosponsored by the state GIS/LIS association

The GIS symposium is sponsored by the GIS/LIS association, CALMIT, the UNL Conservation and Survey Division, and a host of other cosponsors. Similar to the way word processing changed the handling of text, GIS has transformed the way spatial data, formerly displayed on hard-copy maps, is managed and analyzed, making it cheaper, easier to handle, more powerful and more accurate.

One of the emphases of the Nebraska GIS Symposium and a major planner of the symposium is the Nebraska GIS/LIS Association. The three map layers of the state symbolize the capacity of GIS to integrate many data bases. Nebraska GIS/LIS Association image.

The symposium will also feature additional speakers and exhibits by commercial and noncommercial organizations. The call for papers encourages any discussion of leading-edge GIS applications and issues but especially those related to state and local government, symposium literature said. Those interested should submit a 100-word summary of a 20-minute talk by Feb. 1 to Teresa Silence at Applied Data Consultants, Inc.; 3610 Dodge St., Suite 208; Omaha, Neb. 68131; or phone (402) 871-9617; fax (402) 422-0299; or e-mail teresa.silence@adc4gis.com.

The deadline for submitting an abstract for a poster or computer display is March 2. These should be directed to Carl Kinkade at the Lincoln-Lancaster County Health Department; 3140 N St.; Lincoln, Neb. 68510; by phone at (402) 441-6246; or e-mail ckinkade@ci.lincoln.ne.us. Exhibit applications should be submitted by April 15. For more information about the symposium, contact Scott Richert; Lancaster County Assessor's Office; 555 So. 10th St.; Lincoln, Neb. 68508-7463; by phone at (402) 441-7463; or e-mail scrichert@ci.lincoln.ne.us.

More information on the symposium, association or GIS steering committee is available from CALMIT's web site at http://www.calmit.unl.edu. From there, select "GIS/RS Links."

Besides the Nebraska GIS Symposium, the association has sponsored selected GIS forums. The last forum was Nov. 9 at the UNL East Campus Union. Speakers were GIS consultants Marcus Tooze of GIS Workshop and Bill Sheldon of WindStone, Inc., both of Lincoln. Future forums will be posted.

Gap Analysis Project aims to head off species extinction

Biodiversity project completes accuracy assessment, soon to publish land cover map

An accuracy assessment of a detailed land-cover map produced by the Nebraska Gap Analysis Project (GAP) is nearly complete, and a new map showing land cover and land use for the state is getting close to publication, according to landscape ecologist and GAP coordinator Geoff Henebry.

A national cooperative venture of the U.S. Geological Survey's Biological Resources Division and a variety of state, local and nonprofit organizations, GAP is a biological diversity program that seeks to determine the extent to which all native plant and animal species are represented in the present mix of conservation lands. In Nebraska, GAP is administered by Henebry and Jim Merchant, associate director of the Center for Advanced Land Management Information Technologies (CALMIT), a joint program of the Conservation and Survey (CSD) and the School of Natural Resource Sciences at the University of Nebraska-Lincoln.

> *"The goal of GAP, as it's sometimes stated, is to keep common species common."*
>
> *– Henebry*

"The goal of GAP, as it's sometimes stated, is to keep common species common," he said.

Data for land managers to plan for biodiversity

GAP aims to provide information for public and private land managers to plan for biodiversity management, Henebry said. Key to this planning is an assessment of current conditions, for which GAP serves as a coarse filter, assessing the relationship between the habitats of land-based vertebrates, land cover, and the pattern of lands with some formal conservation status.

These lands are mostly in the public sector, but some private conservation organizations like the Nature Conservancy and the Audubon Society also have conservation charters. The focus on public lands aids coordination among the diverse local, state and federal agencies that are responsible for their management.

"Secondly, the land cover map provides an accessible display of the diversity of Nebraska's landscapes," he explained. "It is the logical follow-up to the popular statewide Landsat Thematic Mapper mosaic produced by the project a couple of years ago. We also hope it will be a useful classroom resource for teaching about the state's natural heritage."

In collaboration with Doug Garrison of the High Plains Regional Office of the U.S. Natural Resources Conservation Service, the map has been improved by soliciting expert review from the state's natural resources districts (NRDs), which helped identify misclassified areas, Henebry said.

"We received back more than 80 percent of the maps we sent out. On those maps were specific and general comments. We looked at each comment and assessed its importance within the context of the map," he explained.

Misclassifications were corrected

Significant misclassifications were corrected. The researchers are also following up with revised maps to selected NRDs to increase the rate of response, Henebry said.

The new map will be published at scales of 1:1,00,000, or one mile equals one-sixteenth of an inch, and at 1:500,000, or one mile equals one-eighth of an inch. The project realized another significant increase in accuracy through assimilation of data from the U.S. Fish and Wildlife Service's National Wetlands Inventory, Henebry said. The data have also been cross-compared with national land-cover data recently produced by the USGS Earth Resources Observation Systems Data Center in Sioux Falls, So. Dak. These data include industrial, commercial or transportation land use and hard-to-detect low-density residential areas.

Another improvement from the rather broad classes of the national land cover data is a better portrayal of fallow versus active fields in western Nebraska.

"You can see a very characteristic mosaic out there," Henebry noted.

Platte basin study mapped crop types

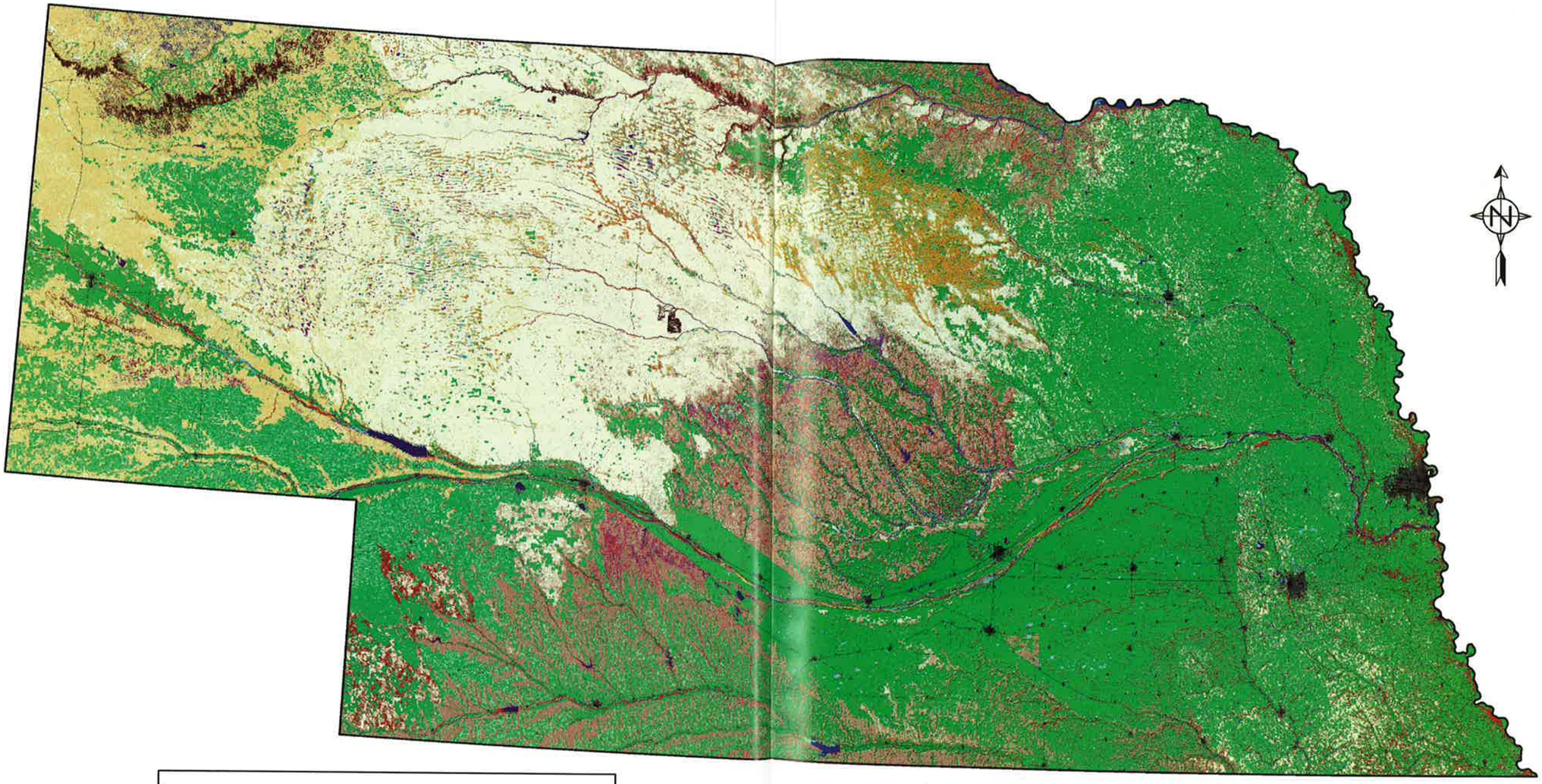
This delineation came from the crop-type mapping CALMIT did for the Platte River and Basin Cooperative Hydrology Study (COHYST; see related article on p. 27). COHYST is a detailed natural resources inventory of the Platte Basin up to Columbus involving CSD, the state Department of Natural Resources, its Game and Parks Commission, the Nebraska and Central Nebraska public power districts and most of the natural resources districts in the basin.

Further compilation of various sorts of information for GAP also led to development of habitat-relationship models.

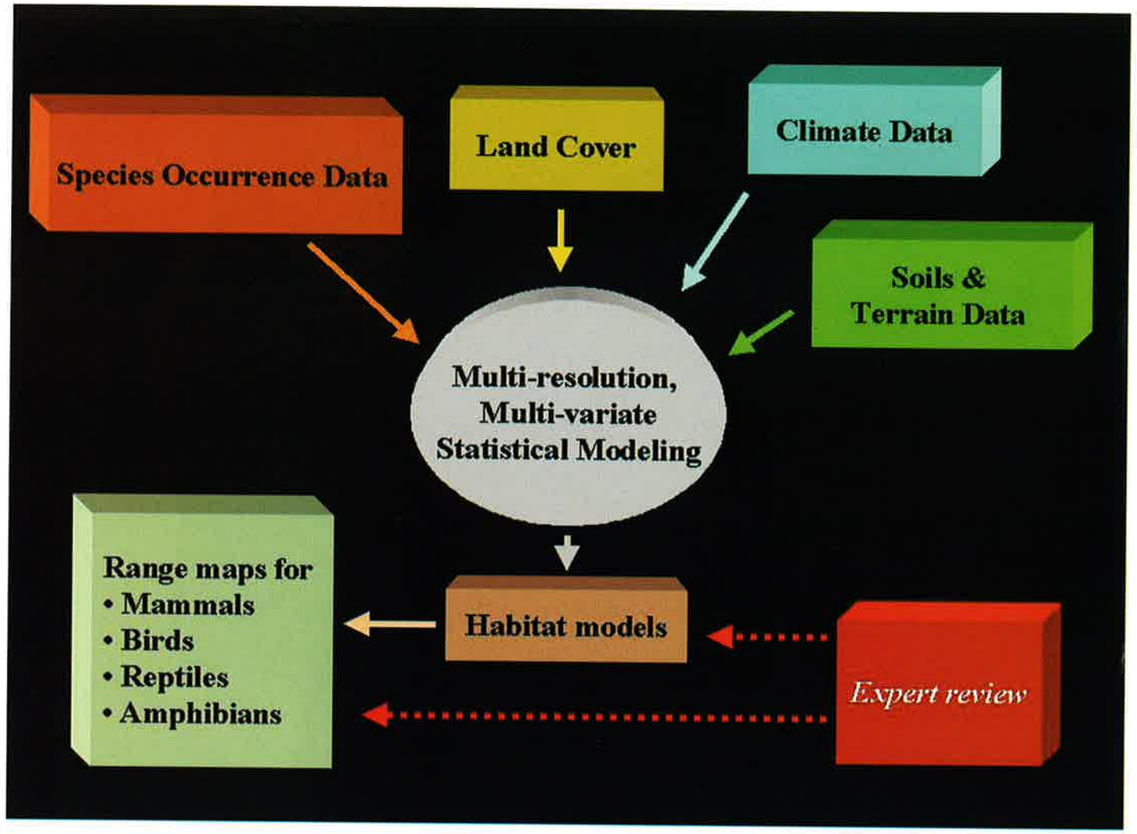
> *"The land cover map provides an accessible display of the diversity of Nebraska's landscapes. We also hope it will be a useful classroom resource for teaching about the state's natural heritage."*
>
> *– Henebry*

"One of the key ideas behind GAP is to build an information infrastructure for biodiversity planning," he explained. "Some models work better than others. We're assessing what works and what doesn't. We want to provide all the information, not just the successes."

This assessment depends in part on an exact geographic referencing of extensive holdings called "vouchers specimens" in the University of Nebraska State Museum and other collections across the country. These represent all or part of an organism collected from Nebraska over the past 30 years and include information on the time, place and other conditions of its occurrence.



Gap Analysis Project Land Cover Map of Nebraska



This flow chart shows the process by which Gap Analysis Project habitat determinations are made and reviewed. CALMIT image.

Physical specimens highest quality data

"They represent the highest quality physical data. You have a physical specimen, as opposed to an observation. But relatively few were georeferenced," he said.

These data have been compiled by Cliff Lemen of the NU State Museum for amphibians, reptiles and mammals collected in Nebraska since 1969. For birds, the GAP project relies on information collected through the National Breeding Bird Survey.

Finally, a couple of important projects slated for the near future involve a regional synthesis of land-cover and habitat data from Kansas, Iowa and North and South Dakota and educational applications for the schools that make use of a large body of land-cover and biodiversity information. Both of these projects are anticipated but will require further funding, as the project ends in about a year, Henebry said.

– by Charles Flowerday, CSD Editor

New publishing from the Conservation and Survey Division

Computer Programs

(All can be downloaded free via the web or are available on CD or diskette for a nominal fee to be determined, about $10.)

CP-1 **Simultaneous Determination of Aquifer Parameters by the Hantush Solution**: X-H. Chen and J.F. Ayers (Version 1.0; 1999)

CP-2 **Synthetic Seismogram Generation for Designing Shallow Seismic Surveys**: J.F. Ayers (Version 2.0; 1999)

CP-3 **Analysis of Travel Time Data by Seismic Refraction Inverse Modeling**: J.F. Ayers (Version 1.0; 1999)

CP-4 **Synthetic Seismogram Generation for Modeled Geologic Sections**: J. F. Ayers (Version 1.00; 2000)

CP-5 **Analysis of Schlumberger Vertical Electrical Soundings by the Method of Steepest Descent**: J. F. Ayers (Version 1.00; 2000)

CP-6 **Generation of Seismic Refraction Travel Times for Multiple Dipping Interfaces**: J. F. Ayers (Version 1.00; 2000)

CP-7 **Analysis of Multiple Dipping Interfaces by the Seismic Refraction Method**: J. F. Ayers (Version 1.00; 2000)

Test-hole Reports

THR-3 **Arthur County** - R. F. Diffendal, Jr. and J. W. Goeke (2000) - 56 p. - $7.00

THR-4 **Banner County** - F. A. Smith (2000) - 47 p. - $7.50

THR-7 **Box Butte County** - F. A. Smith (2000) - 84 p. - $9.00

THR-10 **Buffalo County** - V. H. Dreeszen (2000) - 251 p. - $13.00

THR-15 **Chase County** - V. H. Dreeszen (2000) - 75 p. - $9.00

THR-21 **Custer County** - L. D. Cast, U.S. Bureau of Reclamation (2000) - 201 p. - $12.00

THR-22 **Dakota County** - R. R. Burchett and F. A. Smith (revised 2000) - 9 p. - $4.50

THR-32 **Frontier County** - D. A. Eversoll - (2000) - 93 p. - $9.00

THR-35 **Garden County** - F. A. Smith and J. B. Swinehart (2000) - 91 p. - $9.00

THR-37 **Gosper County** - L. D. Cast (2000) - 68 p. - $9.00

THR-43 **Hayes County** - D. A. Eversoll (2000) - 56 p. - $8.00

THR-48 **Jefferson County** - R. R. Burchett and F. A. Smith (revised 2000) - 45 p. - $7.50

THR-51 **Keith County** - R. F. Diffendal, Jr. and J. W. Goeke (2000) - 115 p. - $10.50

THR-53 **Kimball County** - F. A. Smith (2000) - 153 p. - $11.50

THR-56 **Lincoln County** - J. W. Goeke (2000) - 185 p. - $12.00

THR-57 **Logan County** - P. B. Wigley (2000) - 17 p. - $5.00

THR-62 **Morrill County** - V. L. Souders and J. B. Swinehart (2000) - 106 p. - $10.50

THR-68 **Perkins County** - V. H. Dreeszen (2000) - 112 p. - $10.50

THR-75 **Rock County** - S. Olafsen Lackey, F. A. Smith, L. R. Boryca (2000) - 44 p. - $7.50

THR-79 **Scotts Bluff County** - S. S. Sibray and F. A. Smith (2000) - 49 p. - $7.50

THR-93 **York County** - F. A. Smith - 60 p. (2000) - $6.00

Geological Survey Maps and Charts

GMC-31 **Geologic Maps and Cross Sections Showing Configuration of Bedrock Surfaces, Broken Bow 1 x 2 Degree Quadrangle, East-Central Nebraska**: Souders, V. L., 2000 (USGS No. I-2725) - $8.50 (Includes 11-p. pamphlet.)

Water Survey Maps

GM-62c **Water Level Changes - Predevelopment to Spring 1998** (preliminary 2000, 11" x 17") - $1.50 (This represents the most recent data available at this size).

Land Use Maps

LUM-36 **Center-Pivot Irrigation Systems in Nebraska, 1997**: Compiled by D. Boellstorff, J. Conklin, P. Dappen, S. Hatten, P. Lamb, J. Taylor, M. Tooze, M. Warner, and J. Wolf. (1:1,000,000; 30" x 22"; 2000) - $5.00

General Information Products

GIM-81 **Lake Superior Agate** (card with rock sample and text): R.K. Pabian (2000) - $1

GIM-132 **A Tapestry of Time and Terrain**: By Jose F. Vigil, Richard J. Pike, and David G. Howell, USGS (I-2720), Version 1.0. (1:3,500,000; 2000; "56 x 40") - $7.00 Through computer processing the authors have combined (Thelin and Pike, 1991) *Landforms of the Conterminous United States – A Digital Shaded-relief Portrayal*; and (King and Beikman, compilers, 1974) *Geologic Map of the United States*.

Earth Science Notes

ESN-1 **Environmental Change in the Central Great Plains -- Past, Present and Future**: David Gosselin (2000) - $1

ESN-2 **Environmental Change in the Central Great Plains -- Water Resources**: David Gosselin (2000) - $1

(When ordering, use order number at far left and add state and local sales tax and $3 shipping and handling for first class postage; $2 for fourth-class.)

GIS strategic plan to prevent Tower of Babel in geospatial data

Spatial information at the heart of government work, requires coordination

by Charles Flowerday
CSD Editor

It's a hard sell to the public sometimes, but almost everyone would admit that our roads, bridges, sewers, water service and streets, even our stop lights and street lamps – what we call our physical infrastructure – are important to our common life. And from time to time this network requires care and feeding, upkeep. About this we mostly agree, if grudgingly.

But if, at a hypothetical town hall meeting, you asked about the condition of our spatial data infrastructure, you might get a lot of blank looks. If you added that it's the main way we keep track of our physical infrastructure and a host of other geographic data, and that it's increasingly composed of geographic information systems (GIS), powerful computerized tools for displaying and analyzing spatial data, you wouldn't likely arouse huge passions. But you might find a glimmer of interest in a few. If you explained that these are changing the way we handle geographic information in roughly the way word processing transformed our handling of text, a larger number might be intrigued.

Few detailed cost-benefit analyses have been done, but one study in Montana published two years ago said that every dollar invested in GIS for state and local government would yield between $1.20 and $5.60 in projected benefits, Zink said.

But say you added that 80 percent of the data kept by local governments and most of that at the state and federal levels has to be accurately and geographically referenced. And next you

explained that the best way to do this is through GIS and, furthermore, that the best way to keep many levels of government from duplicating systems that most must use and many must share, thereby saving taxpayers sizable dollars, is to develop a plan for a spatial data infrastructure. Then you might begin to impress upon average folks exactly what is at stake.

Hundreds of thousands of dollars hang in balance

This is the task Larry Zink confronts almost every day. And he knows that many hundreds of thousands of dollars in short-term expenditures and many millions of dollars in long-term savings hang in the balance. Few detailed cost-benefit analyses have been done, but one study in Montana published two years ago said that every dollar invested in GIS for state and local government would yield between $1.20 and $5.60 in projected benefits, Zink said.

Zink is the state coordinator of the Nebraska GIS Steering Committee, the lone paid employee of a committee that evolved out a legislative attempt to keep this boon to researchers and policy makers from becoming a boondoggle, an expensive tower of geospatial Babel. The steering committee arose out of efforts by the University of Nebraska-Lincoln Center for Advanced Land Management Information Technologies (CALMIT) and various state agencies in the early 1990s to better coordinate the money spent on these systems. Informal meetings led to an informal committee that the Nebraska Legislature made a formal part of state government in 1991.

Since then, this committee has been working hard behind the scenes to promote the best possible team play among a host of agencies involved in spatial-data management and land records. Lash Chaffin, utilities section director for the Nebraska League of Municipalities, is committee chair, and Mark Kuzila, director of the Conservation and Survey Division (CSD), one of CALMIT's two parent units, is vice chair.

> *"While most people may not know how a GIS works, they can usually see what they're good for and can appreciate that the implementation of this technology needs the full attention of their legislators because of the large amount of dollars at stake."*
>
> – Kuzila

"While most people may not know how a GIS works, they can usually see what they're good for and can appreciate that the implementation of this technology needs the full attention of their legislators because of the large amount of dollars at stake," Kuzila said.

CSD involved in several ways

CSD has been most deeply involved in several ways: through CALMIT's innovative applications of remote sensing and GIS to a range of natural resource and agricultural issues; through its outreach seminars and workshops; and through CSD's soil survey, state cooperator with the USDA Natural Resources Conservation Service (NRCS; formerly the Soil Conservation Service), along with the state Department of Natural Resources (DNR), in the pioneering of digital soil surveys, Zink said.

And lately, researchers at CALMIT, a joint program of CSD and the UNL School of Natural Resource Sciences, and the NRCS have been finding ways to use this data to create a prototype digital conservation plan. These plans are required for farms enrolled in the federal farm program, Kuzila explained, and applying digital technology should help save time and money.

> *"The strategic plan is an effort to pull together a wide variety of initiatives from lots of sources into one document for policy makers and to highlight the importance of this work."*
>
> – Zink

Since CSD, the state geological survey, has always been involved in geographical survey as well, the birth and growth of CALMIT and its taking geographic data into the digital age was a natural fit, Kuzila said. CSD's soil and water surveys also have made increasing and intensive use of GIS, he added.

Besides CSD and the League of Municipalities, committee members come from the Governor's Policy Office and the state departments of Administrative Services, Natural Resources and Environmental Quality (DEQ), its Game and Parks Commission and Property Assessment and Taxation office, and include the State Engineer, the State Surveyor and the director of Legislative Research. Two members each come from the counties and from at-large gubernatorial appointments, and one each comes from the natural resources and public power districts. The U.S. Natural Resources Conservation Service also has a representative.

Draft plan for spatial data infrastructure

Its main order of business lately has been drafting a plan for building a spatial data infrastructure for Nebraska. The plan gives decision makers the lay of the land in geospatial data and asks them for resources for a coordinated effort.

"The strategic plan is an effort to pull together a wide variety of initiatives from lots of sources into one document for policy makers and to highlight the importance of this work," Zink said. "A parallel effort is also underway at the national level. The Federal Geographic Data Committee and the (federal) Office of Management and Budget are working on a national vision for the cooperative development of this infrastructure."

Under this new paradigm, the goal is the coordination across federal, state and local levels in the development, maintenance and distribution of spatial data. State coordinating bodies, like the Nebraska GIS Steering Committee, will play pivotal roles in making this national data infrastructure a reality, he said.

The first goal of the plan is to develop a set of priority data bases. These data bases can be used to address a number of high-impact issues by a large variety of agencies. They also provide the framework for the development of other data sets, Zink said.

First priority is surface-water data base

The first listed is a surface-water data base, identified by a state water-data advisory committee as the highest priority for water-data development. Designed as a standard statewide reference with updated mapping of surface water features and common identifiers, they also would be used in a host of other ways. These include floodplain mapping; water rights; dam safety; surface water sampling; drainage characteristics such as area, slope, 100-year flood lines and others; fisheries and wildlife management, particularly regarding threatened and endangered species; enhanced lake information for state parks, recreation areas and wildlife management areas; surface water assessments used by DEQ in water quality analysis; maximum daily load analysis and load allocation permits used by DEQ to monitor pollution; bridge design; and mapping buffer strips that provide vegetative filters for agricultural and other chemicals entering surface water.

> *"A parallel effort is also underway at the national level. The Federal Geographic Data Committee and the (federal) Office of Management and Budget are working on a national vision for the cooperative development of this infrastructure."*
>
> – Zink

The next data base listed is water wells. The same water-data advisory committee assigned this its second-highest priority. Part of this effort would be to check and coordinate the spatial accuracy of all wells with a global positioning system (GPS), a satellite-based means of determining exact location. Another part involves exploring the political and practical feasibility of agreeing on a universal identifier system and then getting that marking on each of more than 150,000 wells, Zink said.

Detailed, terrain-corrected aerial photos

Next listed is a statewide data set of terrain-corrected aerial photography, called *orthophotography*, at a fairly detailed scale – 1:12,000 – and a cooperative agreement for updating it. This information is used as a base map in various GIS applications from soil surveys to digital topographic models.

"Nebraska is fortunate in that we have statewide coverage for 1993 imagery available due to the efforts of the former Natural Resources Commission (now DNR)," he said. "An effort is now underway to develop updated orthophotography using 1999 imagery."

Also on the list is the Public Land Survey System, the standard statewide reference database that includes the location of all section and quarter-section corners and a plan for its maintenance. An important related issue is the modernization of all land ownership records to a digital, spatial-data format. Many of these are still done by hand on paper.

"All land ownership records are based on this data," Zink explained. "And the surveying was done more than 100 years ago. We need correct location coordinates. However, on those, we can't use a GPS. It's too costly. But we've found a way to estimate the locations mathematically. We've done the pilot work, but we don't have the resources to take it statewide."

Transportation network also priority

Another priority data base is the transportation network. This includes all state highways, for which the state Department of Roads has good data, but also county roads and local streets and a means for maintaining it. This has important uses in transportation planning, highway and road maintenance; economic development; traffic routing; public safety and emergency response, the plan said.

"A fair amount of work is going on at the local government level with this roads data due to E911, the enhanced 911 plan, which creates a GIS for a reference in assisting emergency response crews. Much of this work is supported by a tax on phone service dedicated to E911 efforts," he explained.

Another is a street address data base, basic to emergency response and transportation routing but also much-needed by human service agencies.

"For the delivery of a lot of human services, it is simply important to know where people live. The (U.S.) Census Bureau develops this type of data, but there is a lot of variability in its spatial accuracy," Zink said.

This has received a good deal of private support, he added, especially from companies that help firms decide where to locate a new business or a branch of an existing one.

The last two priority databases are governmental unit boundaries, which include fast-changing municipal boundaries, handicapped by the lack of consistent reporting to state government; and soil surveys, which are fundamental to farm and ranch management but also to waste-disposal siting, housing and building construction, sanitary lagoons and property assessment.

Emphasis moving to local government

The more recent efforts of the committee and of the recently created, closely allied Nebraska GIS/LIS (Land Information Systems) Association have shifted the emphasis from the state to the local levels of government, Zink explained.

> *"You need a lot of this data at the local government level. But much of rural Nebraska doesn't have the financial or technical resources to manage this task."*
>
> – Zink

"You need a lot of this data at the local government level. But much of rural Nebraska doesn't have the financial or technical resources to manage this task," he added.

To address this, the strategic plan also calls for exploring the feasibility of creating regional mapping and surveying centers, Zink said. These would facilitate state-local partnerships in spatial data development and the sharing of resources within a region. Another related possibility, similar to a successful system in Wisconsin, would be to charge an additional fee for land-ownership transfers to create a fund for these land-record modernization initiatives, he added.

Regarding the overall effort, Zink said, "Everything in government is set to move within an single agency model. Almost all the funding flows this way. But there is an emerging national consensus that in the area of spatial data we need to get out of those silos. We need solutions that are not one-shot. They need to be part of an ongoing effort to develop and maintain this spatial data infrastructure."

Editor's Note: *To assist the Nebraska GIS Steering Committee and the statewide GIS community in general,* Resource Notes *returns to a feature begun a few years ago – reprinting selections from the state GIS Steering Committee update that appear in* GIS Update, *a newsletter designed for Nebraska's GIS users. – CF*

Nebraska GIS Steering Committee Update

***[From July 2000]* A GIS Strategic Plan for Nebraska.** In an effort to better communicate the GIS-related needs, benefits and priorities to policy makers, the GIS Steering Committee is undertaking the development of a strategic plan for coordinated GIS development in Nebraska. The focus of the plan will be to outline the initiatives that are needed to develop a Nebraska Spatial Data Infrastructure to support cooperative GIS development and utilization.

The strategic plan will look at issues such as priority databases, data sharing mechanisms, education/outreach needs, and ways to enhance management/coordination. Input and suggestions from the GIS user community are welcome (see contact information below), and an evolving draft document is available on line at: *http://www.calmit.unl.edu/gis/StrategicPlan2000.pdf.*

DOQ/DEM Pilot Project. The [Department of Natural Resources – DNR] has recently concluded a DOQ/DEM pilot project for Lancaster County. This pilot project follows up on an earlier successful three-year joint effort between the [DNR] and the USGS to develop statewide Digital Orthophoto Quads (DOQs) and Digital Elevation Models (DEMs) for Nebraska. These original DOQs were based on 1993 aerial imagery. The second generation DOQs produced in the pilot project were based on new aerial photography taken statewide in 1999.

In addition to the updated imagery, the pilot project also explored the merits of producing new DEMs based on a denser (10-meter) grid instead of the original 30-meter grid. These higher-resolution DEMs were then used to produce the second generation DOQs. Another innovation of the pilot project was the development of methodologies to produce the DOQs in both UTM and State Plane Coordinate Systems. Based on the results of the Lancaster County pilot, the new Department of Natural Resources is currently considering entering into a workshare agreement with the USGS to produce a statewide dataset of second generation DOQs/DEMs. It is estimated that such an effort could be completed in an 18-month timeframe. [New web site]: http://www.dnr.state.ne.us/. Contact Mahendra Bansal, [DNR], 402-471-3964 for further information.

High Resolution National Hydrography Dataset. Another pilot project currently underway relates to the development of a standard reference dataset for Nebraska surface water features. The USGS and EPA have recently completed the joint development of a National Hydrography Dataset (NHD) for surface water features. This NHD was developed at a 1:100,000 map accuracy scale and features EPA River Reach Coding to provide common identifiers for all stream segments and a continuous centerline network for downstream flow analysis.

The Nebraska pilot project is based on a widespread need for this type of standard surface water dataset for Nebraska and concerns that the 1:100,000 scale would not have sufficient spatial accuracy and detail for many state and local applications. The Nebraska NHD will closely follow the guidelines and standards used to develop the 1:100,000 NHD but will be developed at a 1:24,000 scale. The NHD is developed around watershed boundaries instead of the traditional quad map grid. The Logan Creek watershed area in northeast Nebraska was chosen for the pilot project.

In designing this pilot project, one of the considerations was the level of updating that should be undertaken relative to the existing standard base map of the USGS topographical quad maps. It was decided for the pilot project (and likely for a hoped-for later statewide effort) to base revision on 1993 DOQs. Surface water features that exist on the USGS 7.5 minute topographic quad map will be captured and revised to 1993 DOQ shape and locations. For a more complete delineation of the revision guidelines on the Nebraska NHD, see the contact information below.

The pilot project is an interagency effort involving the Department of Natural Resources (formerly NRC and DWR), Department of Environmental Quality, Game and Parks Commission, and the USDA Natural Resources Conservation Service.

Transportation Database Advisory Committee. An Advisory Committee authorized by the GIS Steering Committee and chaired by the Nebraska Department of Roads is exploring the possibilities for developing and maintaining a statewide transportation geospatial database. NDOR currently has 10,000 miles of state-maintained highways digitized and attributed at a scale of 1:24,000. NDOR is working on another 10,300 miles of local roads (major collector and arterial routes). This leaves approximately 80,000 miles of local roads for which there is currently no known specific plan for digitizing.

The Advisory Committee is looking at the possibility of integrating locally digitized road networks and seeking information on where such local road networks are currently available. Please see contact information below if you can help in this regard. The Advisory Committee is also looking at the data standards to facilitate the on-going integration of transportation data.

Guidelines for Local Government Multipurpose Land Information Systems. Work continues on an intergovernmental Advisory Committee effort to develop guidelines for local government multipurpose land information systems. Following its circulation for comment to the user community, the GIS Steering Committee recently endorsed a draft section on Cadastral Data. The committee is currently working on an "Other Data Layers" section and has in draft form "Introduction" and "What is GIS?" sections. These and the other available sections of the Guidebook are online at: *http://www.calmit.unl.edu/gis/LIS_Stds_Intro.html.*

***[From January 2000]* Water Resources Database Advisory Committee.** The GIS Steering Committee has adopted recommendations from this interagency advisory committee on both groundwater and surface water geospatial database development efforts. In the area of groundwater databases, this Advisory Committee determined that much could be gained by a coordinated interagency effort to enhance the quality of the locational information contained in the registered water wells database. This common reference database is maintained by the [Department of Natural Resources – DNR]. Several state agencies and NRDs have independently collected GPS readings on thousands of water wells. However, there has been no systematic means of getting this enhanced locational data incorporated into the [DNR] registered wells database. The committee developed a standardized format for documenting how the locational data on individual wells was collected. This documentation format is available on the web at: *http://www.calmit.unl.edu/gis/Wat_Res_Reg_Wells_WG_MAD_6-14-99.html.* [DNR] is currently working to develop procedures for accepting and incorporating this enhanced locational well data in a batch process from collecting agencies. Contact Dale Vagts, [DNR], 402-471-2899, for further information.

In the area of surface water, the GIS Steering Committee has adopted Advisory Committee recommendations for a pilot project to develop an enhanced statewide hydrographic database at a 1:24,000 scale map accuracy level. This database would follow national standards developed by EPA and the USGS for a National Hydrographic Dataset (NHD), and it would provide common identifiers for all surface water feature segments. The GIS Steering Committee has adopted a resolution supporting a one watershed pilot project. The Advisory Committee has targeted the Logan watershed in [northeastern] Nebraska for a pilot, largely because of the availability of key source data. Current efforts are underway to define a work share agreement between the USGS and several state and federal agencies on this pilot project effort. Contact Mike Thompson, [DNR], 402-471-1026, for further information.

***[From January 2000]* Geospatial Data Sharing Cooperative.** To further facilitate data sharing among governmental entities, the GIS Steering Committee has expressed its support for the concept of a voluntary, intergovernmental, geospatial data sharing cooperative. To develop this contact, the Steering Committee has formed a committee to develop a draft cooperative agreement incorporating the following general principles.

- Cooperative Members agree to share geospatial data with other Cooperative Members.
- Data sharing Cooperative open to government entities.
- Within Cooperative, all members use same agreement, sign it only once.
- Data shared with Cooperative at cost of duplication or less.
- Option to charge commercial users up to "fair market value" for datasets.
- Option to put data into public domain.
- Data ownership maintained by original producer of dataset.
- Data owner sole source for particular dataset.
- Data errors/corrections returned to data owner for dataset revision at owner's discretion.
- Encourages partnerships with private sector for joint benefits.

For further information on this effort, contact Lauren Hill, Governor's Policy Research Office, 402-471-2414.

– by Larry Zink; transcibed by Karen Stork, CSD

Detailed GIS of land use also part of cooperative hydrology study

Test-hole records basis for better understanding of Platte water system

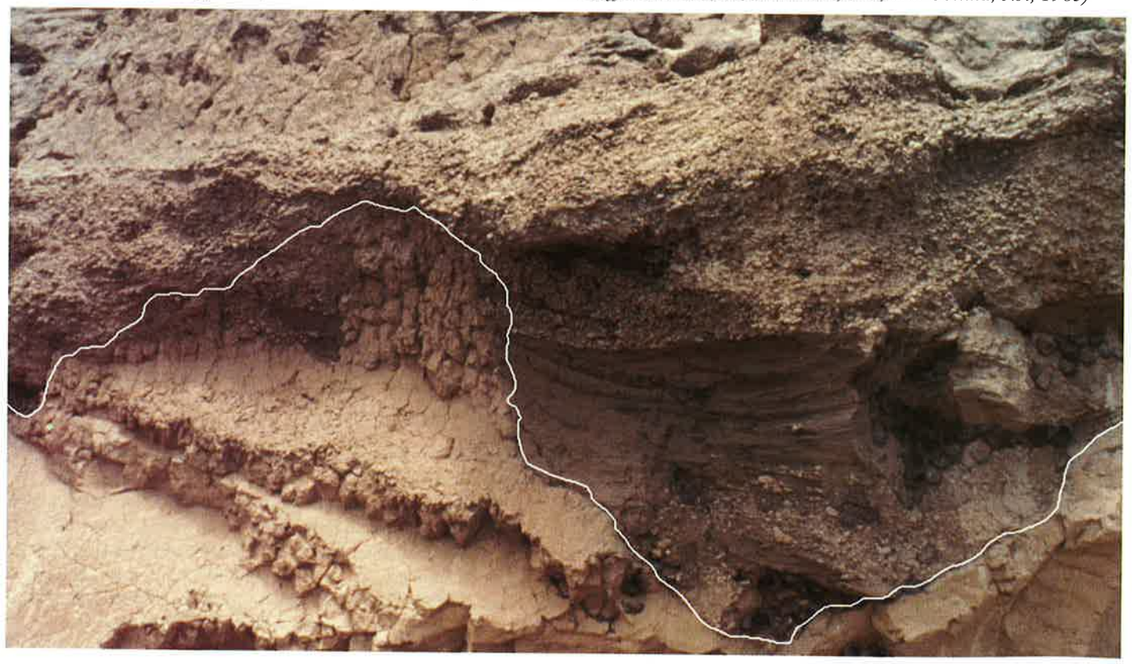
As part of a multi-agency cooperative study of the water resources of most of the Platte River basin, the Conservation and Survey Division (CSD) has published county geologic records from test holes in 29 counties in the basin. Two more such log books are nearing completion, in fulfillment of a contract with the Central Platte Natural Resources District, said Duane Eversoll, CSD research geologist overseeing this part of the study.

This complete study of the water budget of the Nebraska part of the Platte Basin above Columbus, called the Platte River and Basin Cooperative Hydrology Study, involves nine other natural resource organizations besides the University of Nebraska-Lincoln's CSD.

> *"The project should help Nebraska decision makers better understand the dynamics of the Platte Basin water system. It should also help them frame arguments in any potential litigation or negotiations with Colorado and Wyoming over Platte River flows."*
>
> *– Eversoll*

"The project should help Nebraska decision makers better understand the dynamics of the Platte Basin water system. It should also help them frame arguments in any potential litigation or negotiations with Colorado and Wyoming over Platte River flows," Eversoll said. Funding for the $167,000 study came from the Nebraska Environmental Trust.

Through test-hole records and other geologic studies, COHYST aims at a complete understanding of the water system of the Platte Basin. Part of this analysis involves understanding the ancient valleys buried beneath more recent sediments. The result of stream deposits, these valley fills often contain water-bearing sands and gravels. Above is a branching tributary of the North Platte River cut into the compacted sediments of the upper White River Group in Garden County. Valley sides like these developed in the distant geologic past as well. An example of this kind of fill is seen below, where basal Gering Formation sands and gravels fill inner channels in the older Brule Formation, seen in this outcrop in Banner County. The fill is especially evident on the right. Photos by Robert F. Diffendal, Jr., CSD. (From CSD Reprint No. 48; Diffendal, R.F., Jr., Swinehart, J.B., and Gottula, J.J., 1985)



In the near future, CSD plans to integrate the test hole data into a geographic information system (GIS), Eversoll explained. The GIS, to be compiled by Les Howard, CSD GIS specialist, will provide base line data for any further work on the Platte Basin, he added. Duane Mohlman, CSD data systems coordinator, is helping supervise the test hole records effort, Eversoll said.

Test-hole data essential but time-consuming

Most people don't understand the essential but time-consuming nature of amassing test-hole information, Eversoll said. The 31 county test-hole records represent the efforts of 10 geologists, nine from CSD and one formerly with the U.S. Bureau of Land Management.

Asked to speed up the process, CSD declined because it would result in lower quality data, he explained. Starting with the original, sometimes sketchy notations made during drilling from as far back as the early 1950s, geologists then painstakingly examine cores and samples to confirm or revise the initial classification of sediment size, in this case, on thousands of test holes.

If an electric log was made, these samples are also compared to that log, a record of electrical resistance taken down the hole that offers clues to types of sediment nearby. After these records are summarized and typed, they are reviewed by other geologists for accuracy and re-entered. The records provide the most fundamental data on the framework geology of a region, which determines the dynamics, quantity and quality of the groundwater and surface water, he said.

Also detailed model of cropping patterns

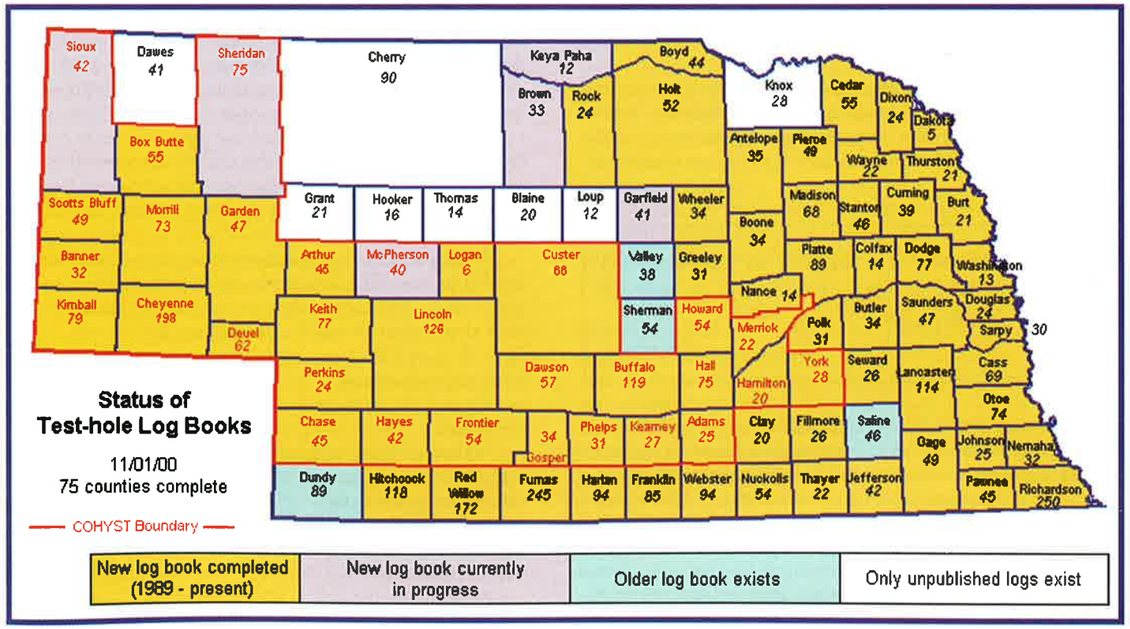
The study also involves detailed modeling of cropping patterns in the study area, explained the principal investigator of part of that study, Marcus Tooze, formerly research coordinator with the Center for Advanced Land Management Information Technologies (CALMIT), a joint program of CSD and the UNL School of Natural Resource Sciences. CALMIT's contribution was called "The Delineation of Land Use Patterns." It focused on seasonal dynamics of native vegetation and crops, including cropping patterns, types of crops and determining irrigated from non-irrigated cropland, Tooze explained.

One of its components was an inventory of irrigation systems, half or more of which by now are center-pivot systems. In compiling the inventory, CSD revived its popular map of center-pivot irrigation systems in Nebraska. However, the money allowed only for one edition, published in the spring, and probably won't continue without additional outside help.

To acquire the center-pivot map, contact CSD at (402) 472-7523 or e-mail csdsales@unl.edu. Last published for 1988, the inventory ended due to a lack of continued outside funding. CSD will seek more avenues for funding an ongoing annual inventory, said CSD Director Mark Kuzila.

These irrigation systems are the large circulating sprinklers that commonly irrigate about 130 acres per pivot or sometimes more. They were invented by a resident of eastern Colorado, Frank Zybach, but were first developed and manufactured in Nebraska. Center-pivot systems surpassed all other forms of groundwater irrigation about two years ago, said Don McCabe, editor of the *Nebraska Farmer*.

Other agencies sponsoring the study are the state Department of Natural Resources, its Game and Parks Commission, the Nebraska and Central Nebraska public power districts and the South Platte, North Platte, Twin Platte, Tri-Basin and Central Platte natural resources districts.



The COHYST test-hole record books are part of an ongoing process of compiling and updating test-hole logs for all of Nebraska's 93 counties. That project's status is shown here. Begun in the late 1980s, it has yielded 75 counties completed and six more in progress. COHYST boundary is in red. Number inside county is total test holes. Map by Duane Mohlman, CSD.

'Incubation' study to pose questions on past, present ecology of Sand Hills

Follow-up proposal seeks NSF funds for holistic look at Earth systems

by Charles Flowerday
CSD Editor

An ambitious multi-disciplinary initiative at the University of Nebraska-Lincoln aimed at better understanding the climatic, ecological, water and earth systems of the Nebraska Sand Hills has received a $100,000 grant from the National Science Foundation for a one-year preparatory study.

The study will bring together scientists with expertise in these areas to assemble data for a more extensive follow-up proposal, explained Geoff Henebry, landscape ecologist with the Center for Advanced Land Management Information Technologies (CALMIT).

The grant is specifically designed to develop questions, not answer them. These will be tested in a larger award if this part of the project is successful, said Dave Wedin, grasslands ecologist with the UNL School of Natural Resource Sciences and the study's principal investigator. Wedin will be examining the region's vegetation structure and soil processes.

In the past, Sand Hills researchers have often examined places where sampling was relatively easy and cost-effective, such as protected areas and university research stations for grasslands work and roadcuts and river banks for geological study, he added.

Beyond targets of opportunity

"We've focused on targets of opportunity but not on a complete vision of a particular landscape," Wedin explained. In general, a substantial amount of expertise on various aspects of the Sand Hills exists at UNL, and this study is an attempt to capitalize on it, he said.

> *"We've focused on targets of opportunity but not on a complete vision of a particular landscape."*
>
> *– Wedin*

The study highlights two new aspects to understanding the Sand Hills, Henebry added. It will merge field research and modeling efforts across ecological and geological time scales. Doing so should integrate research on individual parts of the ecosystem into a complete regional picture that looks in detail at ecological processes such as fire and grazing and climate change.

"It's both exciting and challenging to tie these approaches together across a variety of scales in time and space," Wedin said.

Aiming at dynamic portrait

"We're aiming for a dynamic portrait of the landscape, and one of the objectives of this portrait is to have some basic regional modeling of the water balance," Henebry said. "We want to untangle the climate variability from the human effects."

Crucial to this analysis is modeling of evapotranspiration, or ET. ET is total water lost to the atmosphere through transpiration and evaporation. Transpiration occurs during photosynthesis – when plants use water with sunlight and nutrients to create green matter. During this process, they pump water out of the soil and lose it from their leaves.

> *"An important component of this incubation study is gathering all the minds together."*
>
> *– Henebry*

The effects of atmospheric water, particularly dew and humidity generated mostly by the wetter areas, may allow plants in nearby, more arid uplands to conserve water and limit the effects of shorter droughts, Henebry explained. On the other hand, high rates of ET from either wetlands or upland grasslands may limit the replenishment of the large amount of groundwater stored beneath the Sand Hills.

Thresholds of water balance and distribution

This analysis is one key to understanding exactly what thresholds of water balance and distribution, along with other climatic and ecological variables, would trigger moving dune sand. Some climate change scenarios point to a return to blowing sand and moving dunes in the region, but others are more cautious. One question intriguing researchers is why the Sand Hills didn't fare worse during the 1930s, when blowing soil formed huge dust clouds that darkened skies and blanketed cities far to the east of the most arid regions.

During the Dust Bowl period in the western Great Plains, the Sand Hills were relatively stable, Henebry said. The mitigating effects of the wet areas between dunes on the plant cover of the dune slopes and tops may be one explanation.

Four major questions

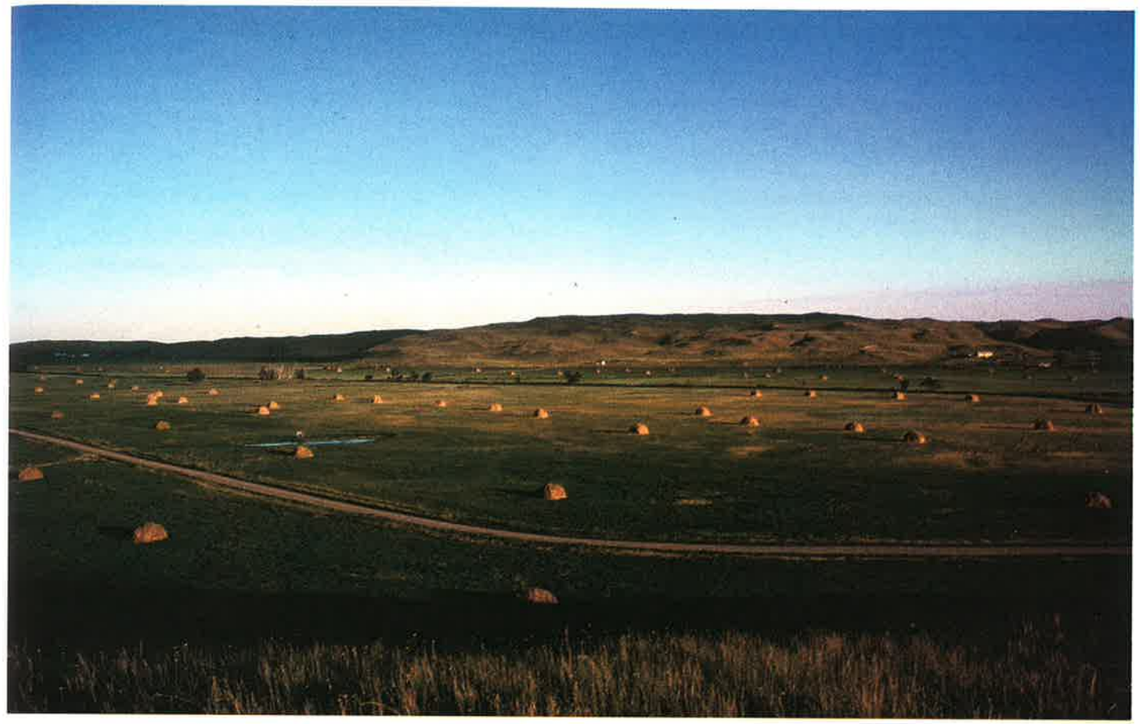
Overall, the study seeks further information on four major questions:

– How do short- and long-term climate changes affect the water table, and in turn, the functioning of the lakes, wetlands and wet meadows in the valleys?

– How do drought, fire and grazing interact to remove vegetation from upland grasslands and allow sand to blow, at local and regional scales and across short- and long-term time frames?

– How does the upland vegetation affect ET, groundwater recharge and the water table?

– What are the dynamics of the relationship between the complexes of wetlands, lakes and wet meadows and the upland grasslands? Do the high rates of ET from the wet areas affect upland grass productivity and stability?



One of the main objectives of the incubation study of the Sand Hills will be to investigate the relationships among the lakes, wetlands and subirrigated meadows such as this and the drier uplands. Photo courtesy of Nebraska Game and Parks Commission.

Henebry also pointed out that a relatively large amount of remote sensing data spanning at least 20 years is available for examining local and regional landscape dynamics. CALMIT has been fundamental to the gathering and keeping of these data, he said.

Information from satellite and aerial imagery

The study will rely on information gathered from satellite and aerial imagery, both long-term and recent; from existing and new geological investigations, in particular of ancient soils, which can offer evidence of climatic and ecological processes; and from field studies on the links between the wet lowlands and the dry uplands, Wedin said.

"An important component of this incubation study is gathering all the minds together. We plan to have a mini-retreat in October," Henebry said. "We want to bring in not only the people mentioned in the proposal but folks from Creighton (University in Omaha), UNO (University of Nebraska-Omaha) and other universities. Over the long term, we also want to forge interdisciplinary, multi-institution ties and be able to put forward a comprehensive, long-term research agenda in the Sand Hills."

The plan also calls for a three-day summer workshop in the Sand Hills to which 20-30 researchers from diverse disciplines will be invited.

In addition to the relevant brain power, the study will use at least four Sand Hills research sites, including a recently acquired University of Nebraska facility at the former Barta Brothers Ranch near Long Pine, slated for work in grassland ecology. Others include the NU Gudmundsen Sandhills Laboratory, the Nature Conservancy's Niobrara Valley Preserve and the conservancy's land in Cherry County – the Jumbo Valley area where wetlands known as "fens" are being restored and studied in conjunction with wet meadows and uplands.

Four sets of studies

Overall, the project consists of four sets of studies:

– Preliminary field work on wetland-upland links, conducted by UNL agronomists Tim Arkebaur and Walter Schacht, Johannes Knops of the UNL School of Biological Sciences and Wedin;

– Remote sensing and modeling of ET, plant productivity and water balance at landscape and regional scales, performed by Henebry and Arkebaur;

– Reconstruction and modeling of long-term links between the climate and the water table, conducted by Sherilyn Fritz of the UNL Department of Geosciences and School of Biological Sciences, Joe Mason of the UNL Conservation and Survey Division and geosciences, Dave Loope of UNL geosciences, James Clark, a Duke University botanist, and Henebry.

– Grassland ecology and dune stability, involving Wedin, Anthony Joern of UNL biological sciences, Schacht, Clark, Mason and Knops.

In general, the team sees the Sand Hills as a model system for studies of biological complexity like this one and UNL as a catalyst for a detailed, regional synthesis of new and existing understandings of how this environment can survive climatological and ecological stress, the proposal said.

Computer series in earth resources offers new programs

by Jerry Ayers
CSD Groundwater Geologist

Synthetic Seismogram Generation for Modeled Geologic Sections

The Windows®-based program *SynGen* generates a synthetic seismogram for a user-defined layered-earth model to be used as an aid in the interpretation of shallow seismic reflection data and as a tool in the design of field surveys. The program is capable of producing a one-dimensional synthetic seismogram for a given geologic column or may be used to create a pseudo two-dimensional synthetic seismogram of more complex stratigraphy. However, in the latter case, the assumption is made that reflectors beneath the trace gather are horizontal and that the trace represents the response of a normally incident ray path coincident with the trace location. Other capabilities of the program are: selection of four types of source wavelets; selection of four methods of displaying the synthetic seismogram; and incorporation of signal attenuation (spherical divergence and distance traveled). *CP-4, Version 1.00, 2000; program by Jerry F. Ayers*

Analysis of Schlumberger Vertical Electrical Soundings by the Method of Steepest Descent

The Windows®-based program *InterpretVES* was developed to process direct current resistivity sounding data collected in the field using the Schlumberger electrode configuration and aid in the interpretation of the resultant vertical electrical sounding curves. The computer program is actually composed of two algorithms that use the method of steepest descent to generate a layered-earth model from the analysis of the sounding curves. One algorithm requires that the user input thickness and resistivity values for each layer as an initial approximation to the actual conditions in the subsurface. The algorithm adjusts the parameters (thickness and resistivity, but not the number of layers) of the initial model until the computed VES curve fits the field VES curve within a user-defined criteria. The other algorithm computes a best-fit model by first assuming the model is composed of as many layers as there are apparent resistivity measurement values and then reducing the number of layers until the computed VES curve fits the field VES curve within a user-defined criteria. *CP-5, Version 1.00, 2000; program by Jerry F. Ayers.*

Generation of Seismic Refraction Travel Times for Multiple Dipping Interfaces

The Windows®-based program *RefractTimes* computes travel times for compressional waves that propagate through a layered earth composed of multiple arbitrarily dipping interfaces between geologic units. Solution to the general travel-time equation by the program not only satisfies the rule of reciprocity for any given model but also provides an accurate representation of layered-earth models when forward and reverse travel times computed for individual geophone positions are graphed as time-distance curves. The general equation is based on the use of layer thicknesses measured perpendicular to the dipping interfaces at refraction points of down-going or up-going ray-path intervals, rather than layer thicknesses measured beneath shot points as in other methods. *CP-6, Version 1.00, 2000; Program by Jerry F. Ayers.*

Analysis of Multiple Dipping Interfaces by the Seismic Refraction Method

The Windows®-based program *RefractSoln* was developed to interpret seismic refraction data collected over a stratified earth with dipping interfaces that separate geologic units. Travel time pairs and spread information are entered into the program using data-entry windows. The processing algorithm uses a set of equations that determine the compressional wave velocities and the vertical depths at geophone locations for each layer represented in the field data. The program can compute layer parameters for up to five layers with any orientation of dip angle. Required input information is obtained from the configuration of the shot-geophone spread used in the survey and from the arrival-time data derived from the field seismogram. *CP-7, Version 1.00, 2000; program by Jerry F. Ayers*

Simultaneous Determination of Aquifer Parameters by the Hantush Solution *(Reprinted from* RN, *Vol. 13, No. 2)*

The Windows application Hantush is designed to determine aquifer parameters simultaneously and uniquely based on time-drawdown data collected from a single observation well near a pumping well partially penetrating a leaky confined aquifer. The program determines the horizontal hydraulic conductivity, the vertical hydraulic conductivity, the storage coefficient, and the leakage factor of the overlying aquitard from field-measured time-drawdown data and other information provided by the user. The program seems to have few limitations. It does require that the characteristics of the observation-well and pumping-well construction be known and that the observation well be located within a radial distance of 1.5b (Kr /Kz)½ from the pumping well (b is the aquifer thickness; Kr is the horizontal hydraulic conductivity; Kz is the vertical hydraulic conductivity). The user must also provide initial estimates of the aquifer parameters. These estimates can be within two orders of magnitude of the actual values; however, if convergence is not achieved, the algorithm results may provide a better estimate to be used in a second trial. In the case of poor quality data, some caution should be exercised in the interpretation of the results since the method produces aquifer property values based on a "best-fit" process. *CP-1, Version 1.0, 2000; program by Xun-Hong Chen, CSD, and Jerry F. Ayers.*

Synthetic Seismogram Generation for Designing Shallow Seismic Surveys *(Reprinted from* RN, *Vol. 13, No. 2)*

Seismic refraction and reflection methods are becoming popular exploration tools in hydrogeological investigations, geotechnical evaluations, environmental assessments, and in some cases, archaeological studies. However, designing a seismic survey to meet the requirements of such applications can be difficult due to problems with survey design and data interpretation. To assist with such problems, the program SynSeis was developed to generate a synthetic seismogram for user-defined field parameters. SynSeis is an interactive Windows application written in Microsoft Visual Basic and developed for IBM-compatible personal computers. The intent is to provide a simple design tool to be used by those not experienced in seismic-data acquisition, but actively involved in the planning and execution of field studies. *CP-2, Version 2.0, 2000; program by Jerry F. Ayers.*

Analysis of Travel-time Data by Seismic Refraction Inverse Modeling *(Reprinted from* RN, *Vol. 13, No. 2)*

SRIM is a Windows adaptation of a seismic refraction inverse modeling computer program (FSIP1) written in FORTRAN by Scott and others (1972) to run on main-frame computer systems and modified later by Haeni and others (1987) to run on micro- and personal computers (version SIPT1). The program generates a two-dimensional model representing a layered-earth depth interpretation. Travel times are picked from seismic records by the user. These times, together with shot point, geophone locations and refraction layer control information, are submitted to the program via a data file. A first approximation delineation of each refraction horizon is obtained by a computer adaptation of the delay-time method. The approximation is then tested and improved by the program through the use of a ray-tracing procedure in which ray travel times computed for the model are compared against field-measured travel times. The model is subsequently adjusted in an iterative manner so as to minimize the discrepancy between computed and measured travel times. *CP-3, Version 1.0, 2000; program by Jerry F. Ayers.*

(Contact CSD if interested. Use order number [CP-1]. All can be downloaded free via the Internet or made available on CD or diskette for a nominal fee to be determined, perhaps $10.)

Eighth of 11 quadrangles that will cover the state published through state-federal program

Geologic quad adds cross sections, base of Ogallala, data density

The most recent contribution to a statewide geologic mapping project has been published and includes features not seen on the seven such quadrangles previously issued.

One such feature is a series of three cross sections showing the geology near the surface, a consideration increasingly important to investigations of groundwater, waste-disposal siting and sand and gravel mining, among others.

A CSD geologist walks the landscape during geologic mapping. Finding exposures such as this is essential to this mapping. It often takes many years to complete because of the footwork involved. CSD photo.

Other additions are two smaller maps showing the base of the top unit of bedrock and the reliability of the data, explained Robert F. Diffendal, Jr., research geologist with the University of Nebraska-Lincoln Conservation and Survey Division (CSD).

"These cross sections and the data on the configuration of the base of the Ogallala Group are important in terms of locating and understanding water resources, as well as for sand and gravel and other minerals," Diffendal said. "The reliability diagram helps people understand where the data are quite good and where they are generally just adequate."

The Broken Bow quadrangle, published by the U.S. Geological Survey (USGS) as part of a cooperative mapping program known as *STATEMAP*, is one of 11 geologic quadrangles 1 degree in latitude by 2 degrees in longitude that will eventually cover the state. Part of a long-term project begun in the 1960s, this publication means the most populous parts of the state have been mapped. Only three more quadrangles, extending from north-central to northwestern Nebraska, remain to be published. Currently in progress are the O'Neill and Alliance quadrangles of north-central and northwestern Nebraska, respectively.

The latest quad includes an 11-page text as well and maps all or major parts of Blaine, Boone, Custer, Garfield, Greeley, Howard, Loup, Merrick, Nance, Sherman, Valley and Wheeler counties. The work was done by Vernon Souders, a former CSD research geologist. Diffendal has worked with the USGS to review the work and complete the publication process since Souders retired nearly two years ago.

When this cooperative mapping project began, Diffendal said, it was important to map the bedrock, largely because the greatest needs were related to oil and gas exploration and water supply. All but the most recent quads, those of the North Platte and Scottsbluff areas, reflect that emphasis. In the last 20 years or so, largely due to the importance of groundwater quality and other environmental geology concerns, the USGS and the state surveys have emphasized mapping near-surface geology.

While it was begun during the era of the previous emphasis, the Broken Bow quad does provide general information on surface deposits through the cross sections and other supplementary data, Diffendal explained.

– by Charles Flowerday, CSD Editor

Geologic maps detail earth resources of lower Platte and Elkhorn valleys

Cooperative mapping targets region of population density, resource concerns

A mapping project in the lower Platte and Elkhorn valleys begun a few years ago by the Conservation and Survey Division (CSD) continues to bear fruit. Geologic maps for the Fort Calhoun and Kennard areas are nearly ready to release to the public. Three more are in review, and two more are in progress, explained Joe Mason, CSD research geologist and principal investigator on the project.

Funded through the U.S. Geological Survey's cooperative mapping program known as *STATEMAP*, the maps detail urban, suburban and rural lands in the central part of eastern Nebraska at a scale of 1:24,000 – 1 mile equals 2,000 feet. The results of the work will be available on compact disk, as well as print-on-demand.

> *"We started out thinking the Platte might be sort of simple – a bedrock valley filled with mostly sand and gravel. But it turns out it's actually very complicated. There are lots of silt and clay layers within that valley as well."*
>
> *– Mason*

The three maps now in review cover an area from Arlington to north of Ashland, the University of Nebraska-Lincoln researcher said. Working with CSD research geologist Matt Joeckel, Mason said it was a challenge to interpret the geology and landscape evolution in these valleys, particularly the Platte.

Thought Platte might be mostly sand and gravel

"We started out thinking the Platte might be sort of simple – a bedrock valley filled with mostly sand and gravel. But it turns out it's actually very complicated. There are lots of silt and clay layers within that valley as well," Mason explained.

This kind of complexity directly affects the management of water quantity and quality in the valley, as well as any potential sand and gravel mining, an important industry in the area, he added.

> *"This is where most of the important sand and gravel resources are in eastern Nebraska."*
>
> *– Mason*

"This is where most of the important sand and gravel resources are in eastern Nebraska," Mason noted.

Some of the complexity comes from layers of silt and clay – finer grained sediments – that tend to redirect and slow the recharge of water into aquifers in a region with considerable irrigation. These aquifers also supply water for major cities in eastern Nebraska. Fremont, Lincoln and Omaha all have well fields in the valley.

Fine-grained layers can create overburden

In addition, if the fine-grained layers create an overburden thicker than five to 10 feet, they can often make mining of sand and gravel too expensive to be worthwhile, he said.

In a region where the density of development increases every year, the mapping also will help developers make smart choices about building homes or businesses, since both flooding and settling of buildings have to be examined.

Mason said he and Joeckel mapped landforms and deposits that have come from large floods of the past, which should help the public better understand the flood hazard in the area, now due mostly to spring ice jams. While the Platte is now partially controlled, builders still need to build above the 100-year floodplain. Present flooding affects mostly farmland, he explained.

Studied changes in channel pattern of Elkhorn

In the Elkhorn River valley, Mason and Joeckel studied the changes in the channel pattern of the river. Straightened in 1912, it has since been returning to its old meandering ways, he explained. Documenting past changes with aerial photography, the researchers looked in detail at the parts of the river that are shifting the fastest.

Some of the most interesting results from the mapping have to do with the landscape evolution and history of the two rivers, Joeckel said. Of broad concern to scientists, they also have implications for the future of the region, as they relate to water supply, agricultural or industrial contamination and building construction.

Of special interest in the Elkhorn Valley were the historic changes in the Elkhorn wrought from channel management and local land use, Joeckel said. In the Platte Valley, the major inroads were in refining the traditional depositional model for sandy braided streams.

Future work will also focus on a better understanding of the Dakota aquifer, used mostly for irrigation and industrial water, the researchers said, and on the Todd Valley south and west of Fremont, an ancient course of the Platte.

– by Charles Flowerday, CSD Editor

CSD continues short course tradition with wells workshop, field trips

In academic year 1999-2000, the Conservation and Survey Division continued to offer its popular field short courses for personnel of the Nebraska Well Drillers Association, the natural resources districts, various state agencies and environmental consulting firms, a tradition begun in 1996.

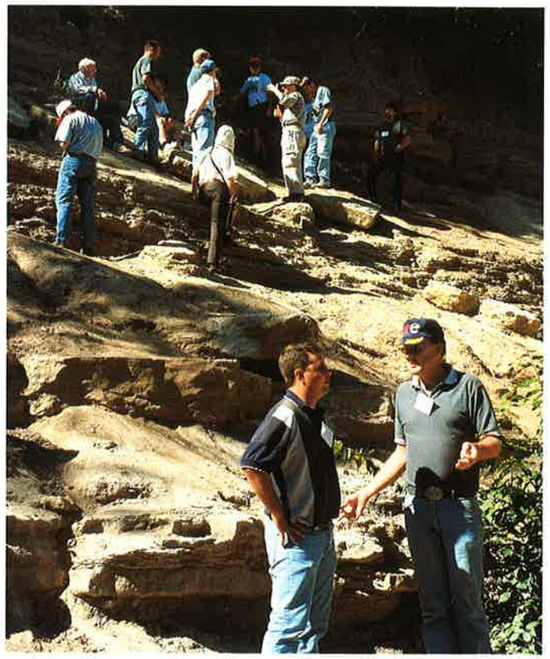
The most recent of these was run in eastern Nebraska Sept. 14 and looked at saline wetlands near Ceresco, geological sections at Schramm Park State Recreation Area, City Wide Quarry and an area east of Mahoney State Park, as well as the island wells of the Lincoln Water System well field in the Platte River near Ashland. CSD Director Mark Kuzila and Duane Eversoll, a former CSD associate director, led the trips. Eversoll, now a research geologist, has been a co-organizer of most of the trips.

> ***Essentially day-long Earth science short courses, these workshops are offered to satisfy continuing education credits for anyone who drills wells or manages or regulates well water, Eversoll explained.***

Essentially day-long Earth science short courses, these workshops are offered to satisfy continuing education credits for anyone who drills wells or manages or regulates well water, Eversoll explained.

Besides the most recent trip this past September, since the fall of 1999, these have involved a trip through southeastern Nebraska in September 1999 that included an examination of the Dakota Formation, the geological material for a secondary aquifer used mostly for non-drinking purposes, and the geology of the Missouri River bluffs area near Indian Cave State Park; a well construction workshop outside the CSD Annex on the UNL East Campus in October 1999; and a tour in late March of the Upper Republican and Middle Republican natural resources districts in southwestern Nebraska.

The well construction workshop included a look by borehole camera at a well constructed with a clear casing that allowed for viewing of proper well-construction procedures, including gravel pack, sealant and screening depth. The camera was provided the state Department of Health and Human Services, cooperators with the state Department of Environmental Quality in putting on the workshop. The well construction was provided by Earnest Well Drilling of Milford, Eversoll said.



Highest up the outcrop (in red cap) is Mark Kuzila, CSD director, and co-leader of a geologic field trip in eastern Nebraska for those who regulate or manage water or install wells. Just below him to the right (in khaki hat), Matt Joeckel, CSD research geologist, explains the geology in and around this exposure in Schramm Park State Recreation Area near Gretna. Photo by Duane Eversoll, CSD.

CSD plans to offer trips to the Panhandle and south-central Nebraska and north-central Kansas next year, he added. If you want to attend these trips or have suggestions for future trips, contact Duane Eversoll at (402) 472-7524; send him an email at deversoll2@unl.edu; or write 113 Nebraska Hall, University of Nebraska, Lincoln, Neb. 68588-0517.

Nebraska's invertebrate fossils on emerging CSD web site

by Roger Pabian
CSD Research Geologist

Nebraska has a rich but little-known history in invertebrate paleontology – the study of the ancient life of animals without backbones.

Most Nebraskans are familiar with the large vertebrate animals that roamed over the state during the Tertiary Period and Pleistocene Epoch of the Quaternary Period – about 66 to 1.6 million years ago and 1.6 million to 10,000 years ago, respectively. These large land animals come from Nebraska fossil beds that are known the world over.

Less well known to the public are the tiny invertebrate fossils that lived in, on and above the substrates of ancient seas that periodically invaded Nebraska in the distant past. But these are equally important to the paleontologists who are constructing a record of past life in the Great Plains.

First reports by Lt. Engelmann

The first written reports of invertebrate fossils in Nebraska were probably those of Lt. H. Engelmann of the U.S. Army about 1857. Engelmann recorded ammonite fossils in south-central Nebraska from what was eventually named the Niobrara Formation of late Cretaceous age. Since then about 200 academic invertebrate paleontologists and amateur collectors have made some significant contributions to understanding the life forms that inhabited the seaways that covered Nebraska many times in the geologic past.

In 1970, the University of Nebraska-Lincoln's Conservation and Survey Division (CSD) published *Record in Rock – A Handbook of Nebraska Invertebrate Fossils* by CSD research geologist Roger K. Pabian. *Record in Rock* still enjoys a wide circulation and much of the information in it is still useful. It attempts to familiarize readers with the taxonomy – biological classification – of invertebrate fossils, but it did not expand on other areas of paleontology such as paleoecology – ancient environments; biostratigraphy – classifying rock layers by fossil content; or organic evolution – using fossils to interpret events in Earth's history. *Record in Rock* is now being updated to include many case histories based on Nebraska's invertebrate fossils.

Spurred by success of previous web pages

During the past year or so, CSD web site administrator Duane Mohlman, and Pabian examined the idea of putting material about invertebrate fossils on the CSD web site. The success of previous web pages on agates and birthstones showed that there was a great deal of professional and popular interest in these areas and that a web page devoted to invertebrate fossils could also generate strong interest.

To date, the invertebrate fossil page contains images of some of the crinoids and arthropods from the late Pennsylvanian and early Permian strata of Nebraska. In addition to taxonomic names of the fossils, the web user can find interpretations of these fossils. More images and interpretations are to be added to the page in the near future. There will be new sections covering brachiopods, mollusks, bryozoans, and cnidarians. All of these will keep the readers informed of new developments in Nebraska's invertebrate fossils until the successor of *Record in Rock* is published. The invertebrates web page can visited at: http://csd.unl.edu/csd/programs/fossils.htm.

Selected publications related to this issue

Geological Survey Papers

GSP-17 **Correlation of Formations Drilled in Test Holes for Interstate 480 Bridge between Omaha, Nebraska, and Council Bluffs, Iowa**: Burchett, R. R. (1965) - $4

Geological Survey Investigations

GSI-2 **Geology of the Liquid Propane Gas Storage Facility near 63rd and Oak Streets, Omaha, Nebraska**: Burchett, R. R. (1969) - $4.50

GSI-10 **Geology of the Liquid Propane Gas Storage Facility Near Greenwood, NE:** Burchett, R.R. (1996) - $10

Field Guides

FG-2 **Cass County – Weeping Water area**: Pabian, R. K. (1977) - $1

FG-3 **Sarpy County – Gretna State Fish Hatchery Area**: Pabian, R. K. (1977) - $1

FG-8 **Greeley County – Chalk Mine State Wayside Area**: Pabian, R. K., and Swinehart, J. B. (1977) - $1

Guidebooks

GB-10 **Geologic Field Trips in Nebraska and Adjacent Parts of Kansas and South Dakota--Parts of the 29th Annual Meeting of the North-Central and South-Central Sections of the Geological Society of America**: Diffendal, R.F., Jr. (chair) and Flowerday, C.A. (editor) (1995) - $8.50

Geo-resources Brochures

GR-3 **Drying Out Wet Basements**: Kuzila, M. S. - Free

Geologic Maps and Charts

GMC-1 **Geologic Bedrock Map of Nebraska**: Burchett, R. R.; color print (1:1,000,000; 1986) - $7.50

GMC-2 **Bedrock of Nebraska with Geologic Time and Rock Chart**: Burchett, R. R., and Pabian, R. K.; color print (11" x 17"; 1991) - $1.50

GMC-20 **Bedrock Geologic Map Showing Thickness of Overlying Quaternary Deposits, Fremont Quadrangle and Part of Omaha Quadrangle, (USGS Map I-905)**: Burchett, R. R.; Reed, E. C., and Dreeszen, V. H.; color print (1:250,000; 1975) - $8.50

GMC-27 **Quaternary Geologic Map of the Platte River 4 x 6 Degree Quadrangle, United States (USGS Map I-1420 [NK-14]):** Swinehart, J. S., Dreeszen, V.H., Richmond, G. M., Tipton, M. J., Bretz, R., Steece, F. V., Hallberg, G. R., and Goebel, J. E. (1:1,000,000; 1994) - $8.50

GMC-31 **Geologic Maps and Cross Sections Showing Configuration of Bedrock Surfaces, Broken Bow 1 x 2 Degree Quadrangle, East-Central Nebraska (USGS No. I-2725)**: Souders, V. L. (1:250,000; 2000) - $8.50

Correlations and Cross Sections

CCS-1 **General Correlation Chart of Nebraska Basins**: Reed, E. C., and Svoboda, R. F. (1957) - $4

CCS-12 **E-W Cross Section of Cambrian Through Cretaceous from Dundy to Cass Counties**: Burchett, R. R. and Carlson, M. P. (1950) - $7

CCS-16 **Block Diagram Showing Bedrock Geology of Nebraska**: Reed, E. C. (1958; 8-1/2" x 14") - Free

CCS-17 **Generalized Geologic Cross-Section for Groundwater Regions**. - $6 each

a) Region 1 - Sand Hills (North-South, East Half and West Half)
b) Region 2 - Platte River Valley
c) Region 3 - Missouri River Lowlands
d) Region 4 - South Central Plains
e) Region 5 - Southwestern Tablelands
f) Region 6 - Northern Panhandle Tablelands
g) Region 7 - Southern Panhandle Tablelands
h) Region 8 - East Central Dissected Plains
i) Region 9 - Republican River Valley and Dissected Plains
j) Region 10 - Northeast Glacial Drift Area
k) Region 11 - Southeastern Glacial Drift Area
l) Region 12 - North Central Tablelands

Water Survey Papers

WSP-63 **Hydrogeology of Garfield and Wheeler Counties, Nebraska**: Lawton, D. R., and Hiergesell, R. A. (1988) - $8.50

WSP-70 **Hydrogeology of Parts of the Twin Platte and Middle Republican Natural Resources Districts, Southwestern, Nebraska**: Goeke, J. W., Peckenpaugh, J. M., Cady, R. E., and Dugan, J. T. (1992) - $13.50

WSP-73 **Fact and Figures About Nebraska Rivers (from a report for the 1991 Nebraska Water Conference):** Bentall, R. (1991) - $15

Test Hole Reports

Test hole reports (THRs) compile the records of test holes, by now drilled in every county in the state. They have little or no narrative but large amounts of data of primary use in groundwater geology, but also in building construction, waste-disposal siting and mining. The sediment thicknesses are recorded for every hole. About 4,700 test holes have been drilled in Nebraska by the division in cooperation with the U.S. Geological Survey to determine the types of rock or unconsolidated sediment beneath the land surface, the order of their occurrence, the depth to the water table, and the thickness of water-bearing sediments. Price varies by county; contact CSD.

Other Groundwater Maps

GM-54 **Configuration of Water Table, Spring, 1979** (except where otherwise indicated): printed on U. S. Geological Survey 1 degree x 2 degree base (see topographic map index) (1:250,000) - $4 each: Alliance (fall 1971: Souders, V. L., and Freethey, G. W.); Broken Bow; Fremont; Grand Island; Lincoln; McCook; North Platte; O'Neill; Scottsbluff (fall 1971: Souders, V. L., and Freethey, G. W.); Sioux City; Valentine quads.

GM-55 **Base of Principal Aquifer, 1980**; printed on U. S. Geological Survey 1 degree x 2 degree base (see topographic map index) (1:250,000) - $4 each: Alliance; Broken Bow; Fremont; Grand Island; Lincoln; McCook; North Platte; O'Neill; Scottsbluff; Sioux City; Valentine quads

GM-56 **Thickness of Principal Aquifer, 1980**; printed on U. S. Geological Survey 1 degree x 2 degree base (see topographic map index) (1:250,000) - $4 each: Alliance; Broken Bow; Fremont; Grand Island; Lincoln; McCook; North Platte; O'Neill; Scottsbluff; Sioux City; Valentine quads.

Soil Maps

SM-2 **Quadrangle Soil Maps, 1981**, color print on USGS 1 degree x 2 degree base (1:250,000) - $4 each: Alliance; Broken Bow; Fremont-Omaha; Grand Island; Lincoln-Nebraska City; McCook; North Platte; O'Neill; Scottsbluff; Sioux City; Valentine quads.

SM-3 **General Soil Map of Nebraska**: Kuzila, M. S., compiler (page size; 1988) - Free

SM-4 **General Soil Map of Nebraska**: Kuzila, M. S., compiler (1:1,000,000; 1990) - $7.50

Land Use Maps

LUM-32 **Seasonal Land Cover Regions of the Conterminous United States**: Loveland, T. R., Merchant, J. W., Ohlen, D. O., Brown, J. F., and Reed, B. C. (1:7,500,000; 1993) - $6

LUM-33 **Pesticides and Groundwater — An Applicator's Map and Guide to Prevent Groundwater Contamination:** M. S. Kuzila and others, a cooperative project by CSD, the Cooperative Extension Service and the Nebraska Department of Agriculture, available for the entire state. Some counties are combined (scale varies — approximately 1:250,000) - Free

LUM-34 **Satellite View of Nebraska**: Eve, M. (1:1,000,000; 1997) - $10

LUM-35 **Satellite View of Nebraska**: Eve, M. (1:500,000; 1997) - $15 (Same as above in larger format.)

LUM-36 **Center-Pivot Irrigation Systems in Nebraska, 1997**: Tooze, M. and others (2000; 1:1,000,000) - $5

Resource Reports

RR-2 **Soils of Nebraska**: Elder, J. A. (1969) - $8

RR-12 **Flat Water: A History of Nebraska and Its Water**: Kuzelka, R. D., project manager and Flowerday, C. A., editor (1993) - $27.50

Resource Atlases

RA-2 **Groundwater Quality of the Central Platte Region, 1974**: Exner, M. E., and Spalding, R. F. (1976) - $7

RA-3 **Groundwater Quality Atlas of Nebraska**: Engberg, R. A., and Spalding, R. F. (1979) - $7.50

RA-4a **The Groundwater Atlas of Nebraska**: Flowerday, C.A., Kuzelka, R. D., and Pederson, D. T., compilers (revised 1998) - $8

RA-5b **An Atlas of the Sand Hills**: Bleed, A. S., and Flowerday, C. A., editors (revised 1998); paper bound - $25
This third edition includes a new chapter on insects.

Educational Circulars

EC-1 **Record in Rock—A Handbook of the Invertebrate Fossils of Nebraska**: Pabian, R. K. (1970) - $9

EC-8 **A Guide to the Practical Use of Aerial Color-Infrared Photography in Agriculture**: Rundquist, D. C., and Samson, S. A. (1988) - $8

EC-10 **Geology, Geologic Time and Nebraska:** Carlson, M. P. (1993) - $9.

EC-11 **Fundamentals of Groundwater Contamination**: Pederson, D. T. (1994) - $8

Miscellaneous Publications

MP-37 **Guidelines for Decommissioning Water Wells--How to Plug Water Wells:** Eversoll, D. A. (CSD), Hay, D. (Cooperative Extension), and Tremblay, R. (state Dept. of Health and Human Services) (1995) - $5

MP-42 **The Summer It Rained: Water and Plains Humor**: Welsch, R.L. (Reprinted 1997) - $5

MP-43 **So You Need a Water Well? A Consumer's Guide to Homeowners' Drinking Water**: Prepared cooperatively by the Nebraska Well Drillers Association and CSD (1997) - Free

GIM-2 **Resourceful Scenes From Past and Present**: Pabian, R. K.; color (1988) 11" x 17" and poster - Free

GIM-3 **Photograph of Relief Model Map of Nebraska, 1958**; 8-1/2" x 14" print - Free

GIM-5 **Shaded Topographic Map of Nebraska, 1971**; 8-1/2" x 11" print - Free

GIM-6 **Topographic Regions Map, 1973**; 8-1/2" x 11" color - Free

GIM-10 **Nebraska Natural Resources District Boundaries** (11" x 17" and page size) - Free

GIM-11 **Annual Outflow and Annual Inflow of Water from/to Nebraska, 1950-94** (page-size chart) - Free

GIM-13 **Annual Departures from Average Annual Precipitation in Nebraska, 1850-1995 / Annual Installation of Irrigation Wells** (page size) - Free

GIM-14 **Postulated Evolution of Platte River and Related Drainages:** Souders, V. L., Swinehart, J. B., Dreeszen, V. H. (1990) - Free

GIM-54 **Native Vegetation Map of Nebraska**: Kaul, R. B., and Rolfsmeier, S. B. (1:1,000,000; 1993) - $7.50

GIM-89

-101 **Regional Hydrogeologic Summaries** from ***Domestic Well-water Quality in Rural Nebraska — A Data-analysis Report for the Nebraska Department of Health and Human Services***: Gosselin, D.C., Headrick, J., Chen, X-H., Summerside, S. (1996) - free.

Summaries available for the following regions:

GIM-89 - **Sand Hills** (Groundwater Region 1— GR-1);
GIM-90 - **Platte River Valley** (GR-2);
GIM-91 - **Missouri River Lowlands** (GR-3);
GIM-92 - **South Central Plains** (GR-4);
GIM-93 - **Southwestern Tablelands** (GR-5);
GIM-94 - **Northern Panhandle Tablelands** (GR-6);
GIM-95 - **Southern Panhandle Tablelands** (GR-7);
GIM-96 - **East Central Dissected Plains** (GR-8);
GIM-97 - **Republican River Valley and Dissected Plains** (GR-9);
GIM-98 - **Northeast Glacial Drift Area** (GR-10);
GIM-99 - **Southeastern Glacial Drift Area** (GR-11);
GIM-100 - **North Central Tablelands** (GR-12);
GIM-101 - **Hat Creek-White River Drainage Basin** (GR-13)

GIM-102

-114 **Regional Analysis of Rural Domestic Well-water Quality** from ***Domestic Well-water Quality in Rural Nebraska — A Data-analysis Report for the Nebraska Department of Health and Human Services*** : Gosselin, D.C., Headrick, J., Chen, X-H., Summerside, S. (1996) - $5.50 each.

Summaries available for the following regions:

GIM-102 - **Sand Hills** (Groundwater Region 1— GR-1);
GIM-103 - **Platte River Valley** (GR-2);
GIM-104 - **Missouri River Lowlands** (GR-3);
GIM-105 - **South Central Plains** (GR-4);
GIM-106 - **Southwestern Tablelands** (GR-5);
GIM-107 - **Northern Panhandle Tablelands** (GR-6);
GIM-108 - **Southern Panhandle Tablelands** (GR-7);
GIM-109 - **East Central Dissected Plains** (GR-8);
GIM-110 - **Republican River Valley and Dissected Plains** (GR-9);
GIM-111 - **Northeast Glacial Drift Area** (GR-10);
GIM-112 - **Southeastern Glacial Drift Area** (GR-11);
GIM-113 - **North Central Tablelands** (GR-12);
GIM-114 - **Hat Creek-White River Drainage Basin** (GR-13)

Reprint Series

RS-48 **Characteristics, Age Relationships, and Regional Importance of Some Cenozoic Paleovalleys, Southern Nebraska Panhandle**, *in* Ter-Qua Symp. Series, v. 1: Diffendal, R.F., Jr., Swinehart, J.B., & Gottula, J.J. (1985) - $1.50

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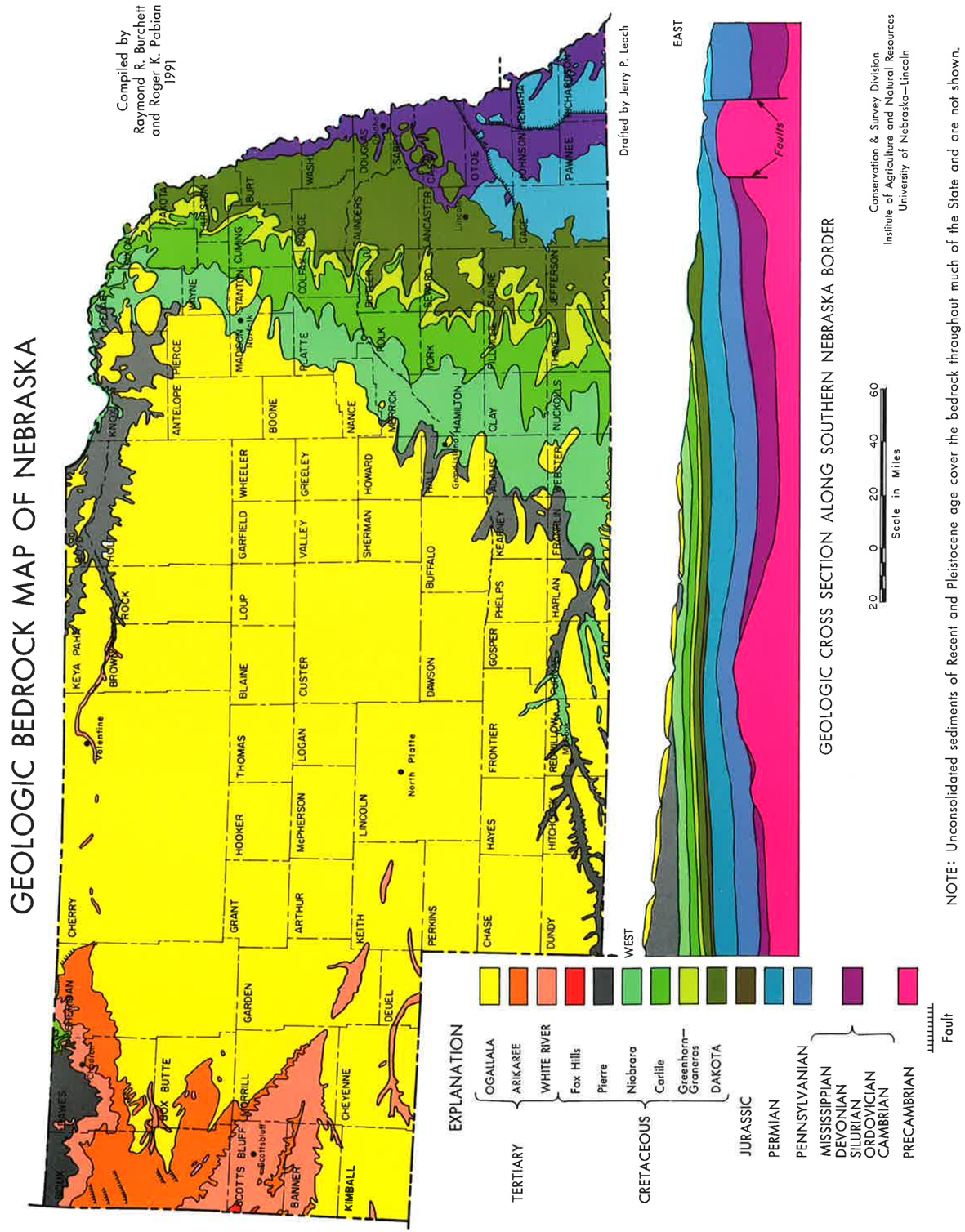

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